SCHOOL HYGIENE

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SCHOOL HYGIENE

BY

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To

MY WIFE

PREFACE

It is the purpose of this book to set forth in a simple and untechnical way some of the hygienic requirements of school life, and to suggest, whenever it seems necessary, how these requirements may be put into practice. No attempt has been made to treat any phase of the subject exhaustively. The purpose has been to select the most important topics, and to deal with them in a manner as simple as is consistent with the truth It has not been written for the specialist in school hygiene, but for busy teachers, and the author hopes that it will do some small service in convincing them of the great importance of making school life wholesome and healthful, and of instructing the children, directly and indirectly, in matters relating to hygienic living in school and at home.

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SCHOOL HYGIENE

CHAPTER I

INTRODUCTORY

THE MEANING OF HYGIENE AND ITS RELATION TO EDUCATION

The Science, Hygiene. — Hygiene is a term applied to that organized body of facts relating to the preservation of health. School Hygiene is the branch of this science which has to do with the conservation and development of the health of school children.

It is the business of teachers to guard and promote the health of the children committed to their care during school hours, as well as to instruct them in the various branches of a school curriculum. Teachers must know what constitute healthful school conditions in order to be able to manage and to direct the children accordingly.

Importance of Health and Physical Vigor. — No amount of mental acumen can take the place of physical vigor. The happiness and final usefulness of the individual is limited by his ability to perform the duties of life energetically and joyously. There can be no true and lasting culture unless it is founded upon the basis of a strong, well balanced body and vigorous health. That intangible complex popularly known as character depends upon both mind and body. The safest and surest way to start a child on the road to success and usefulness is to develop his body properly and to furnish him with every opportunity and condition for good health and a complete, well-rounded physical growth. There are thousands of children in our schools to-day who would be far better con-

ditioned for normal development if they were allowed to learn through play, and to develop their bodies through the exercise and freedom that nature so strenuously demands. Health is frequently confirmed or destroyed in the first years of life. The results of experiments with open-air schools prove beyond doubt that abundant fresh air is vital to the needs of children, while experiments with half-day sessions in schools, followed or preceded by a half day of open-air work and play, prove that for many children much time is now wasted in full-time schools, and their normal development is retarded. Our schools are still cursed with the doctrine that teaches people to neglect their bodies and even to mortify the flesh, in order to gain spiritual control and to subdue their passions. It would be a great blessing if the Greek ideal of physical and spiritual unity could be reëstablished in the world, and the dogma of educational disconnectedness banished forever.

The School and Health. — The school exists not only for the welfare of each child in attendance, but also for the welfare of the state and the nation. We hear much in these days about conservation of national resources, but we generally have in mind those material things that nature has lavished upon us, such as fertile soil, forests of valuable timber, and mineral deposits of great value. These are very important considerations, but conservation means more than this. When applied to human life in its broadest sense, it means the intelligent care of the health and vigor of our people, intellectually, physically, and morally. The greatest asset of an individual, as well as of the state, is trained intelligence, controlled by high moral ideals, and made effective and sane through vigorous physical powers. School life must therefore be organized and directed to strengthen and conserve these powers, else the highest interests of all cannot be protected and maintained. The school life of children furnishes the best social opportunity for the development of this highest sort of conservation. The health and vigor of the people of

any nation is the only firm foundation upon which moral, intellectual, and spiritual supremacy can be built; and this fact must become more and more significant to the teachers of this land, else our intellectual progress will cease and moral delinquency will increase at a rapid rate.

Practically all teachers are striving with one accord and with commendable energy to increase the intellectual vigor of our people; but few give equal thought to the duty of conserving the health of the children, and fewer still recognize the great importance of increasing the physical stamina of the coming generations. Most teachers are satisfied if lessons are learned and examinations are passed. The time has gone by in this country when schools should exist merely for intellectual drill, and the conning of lessons. The time has come to give larger attention to physical well-being and normal physical development.

Divisions of Hygiene. — School hygiene may be roughly divided into two main divisions. One division has to do with the physical environment of the child during his school life; the other takes cognizance of the laws of mental hygiene as illustrated by the proper adjustment of the subjects of the curriculum to the mental powers and needs of the children. It is wrong to compel the children to congregate in a schoolhouse for the sake of acquiring an education, and then to neglect to furnish them with sufficient pure air, good light, comfortable seats, and proper materials with which to work. It is likewise culpable to furnish them with teachers either ignorant or neglectful of the laws of mental economy, as illustrated in the most wholesome and the most effective order of mental discipline. A teacher who irritates and balks the mind in its natural desire to acquire that which it can normally assimilate, is thoughtlessly fostering a distaste for learning that cannot help influencing the whole mental life of the individual. A boy who acquires a dislike for his studies is rarely able to command, later in life, that mental persistency

that will give him mastery over the problems of life as he meets them. The mind may be warped as well as the spinal column. The questions relating to fatigue, and maladjustments of subject matter to mental growth and physical capabilities, are comparatively new questions, but their novelty does not lessen their importance.

Educating the Community through the School. — Granted that teachers know the value of play, of hygienic schoolrooms, of the methods of handling all branches of the curriculum so as to create an appetite for learning, it still remains true that the people as a whole are ignorantly demanding unnatural lives for their children. A teacher's duty must therefore include the teaching of sound doctrines of health to her pupils. Indirectly, at least, the homes of the people should be influenced so that sanitary and wholesome living will acquire a larger and larger significance.

The School and the Home. — The school cannot and should not take the place of the home, but it will surely fail of its mission if it does not become an important factor in the making of the home. If every rural school-teacher could and would set to work, wisely and courageously, to make the school environment completely wholesome and pure, and to teach the children the facts relating to personal and community hygiene, country life would soon make rapid strides toward health and salutary living. The same thing, with such modifications as city life demands, could be said with equal cogency to teachers in the city.

TOPICS FOR FURTHER STUDY

1. What in general are the relations of good health to the development and maintenance of good character?
2. What are the elements that have entered into the decline and downfall of nations?
3. What can teachers do to aid in the development of the doctrine of eugenics (the science of being well born)?

4. What are the fundamental requisites for the development of self-control?

5. What relation, if any, does good health and normal physical development bear to crime and criminality in general?

6. It has been said that a sane mind necessitates a sound body. Do the studies of insanity and degeneracy prove this to be true? Carefully formulate the reasons for your conclusions.

7. Has illness in your own case influenced in any definite way, temporarily or permanently, your own character?

8. Does bad air, fatigue, or loss of sleep influence the behavior of your pupils? Why?

9. What results have been observed in the physical and mental progress of children after treatment for hookworm disease? Anæmia? Adenoids?

10. Is it very often true that the best way to develop the mental and moral natures of dull children is first to see that their health and physical powers are put into good condition? Why?

11. Did the Greeks waste the children's time and delay their mental and moral growth by using practically half of the school day for games and physical exercises? Give good reasons for your answer.

SELECTED REFERENCES

ALLEN, W. H. *Civics and Health.* Boston, 1909. 411 pp., illus.

AMERICAN ACADEMY OF MEDICINE. *Conservation of School Children.* Papers and Discussions of Conference at Lehigh University, April 3 and 4, 1912. Easton, Pa., 1912. 293 pp.

BURGERSTEIN, L. *Some Remarks on the Relation of Mind and Body.* Pedagogical Seminary, v. 17, pp. 29–39.

CLOUSTON, T. S. *The Hygiene of Mind.* London, 1911.

DUKES, C. *Health at School considered in its Mental, Moral, and Physical Aspects.* London, 1894. 498 pp.

FISHER, H. W. *Making Life Worth While.* New York, 1910. 318 pp.

HUTCHINSON, WOODS. *We and Our Children.* New York, 1911. 371 pp.

LINCOLN, D. F. *Sanity of Mind.* New York, 1900. 177 pp.

CHAPTER II

PLAY AND PLAYGROUNDS

The Play Instinct. — Can you not remember your keen desire for play during childhood? Whence came the exquisite pleasure of playing dolls with your girl friends, of skipping the rope, of playing ball, of playing hide and seek, and the many other games so dear to the heart of childhood? It is a general rule that where natural delight and joy issue from a given human activity, such activity ministers to the needs of human life. Naturally this rule, as all others, is subject to misuse and erroneous interpretation. Bad habits in time become enjoyable, but usually nature rebels at the start, and she always does at the last.

The instinct for play is one of the fundamental demands of child life, because it is one of Nature's most effective methods of prompting the child to react to his environment, both physical and social. Suppose that we could find a normal child devoid of this instinct, so that all that he learned must be taught him directly by others. How long would it take you to teach him how to run, how to judge distance, how to speak, how to throw a ball, or how to coöperate with his fellows? Teachers will agree that there is no more difficult task than the attempt to teach a child to do a thing for which he has no desire. The play spirit in early years is preëminently the spirit of learning, and the delight resulting from play is Nature's remuneration and incentive. Day after day, prompted by the love of fun and the joy of liberating his surplus energy, the child strives on his own initiative to do the things that he needs to learn. He multiplies his experience a thousand fold in his early years by reason of the contacts that play induces.

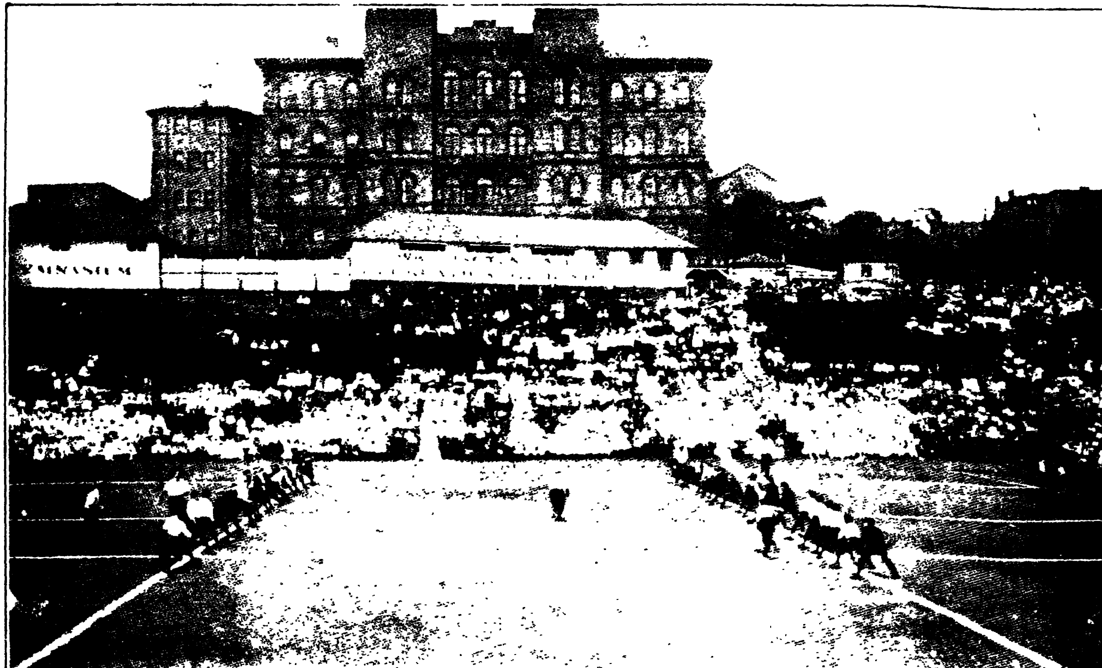


FIG. 1.—PLAY FESTIVAL, PITTSBURGH, PA.

This is fine; but playing Indian in the woods would hark back to deeper instincts. (Courtesy Playground Association of America.)

Play and Infancy. — All of the higher animals have a more or less prolonged period in their lives when the play instinct is dominant. This period always corresponds to the stage in their development when the education that each needs for his life's work is most readily and fundamentally acquired. At first the kitten is practically blind, and his muscular life is imperfectly developed and uncoördinated. At this stage of his growth there is no attempt at play. Observe how much he behaves like an old decrepit cat. But in a comparatively short time the play instinct is dominant, and he is then all for play. He learns how to hide, how to jump, how to defend himself with tooth and claw, how to crouch, how to close stealthily on his prey, and how to be as quick as a well-developed cat ought to be. Change your terms so as to make the activities correspond to the demands of human life, and you may substitute the word boy or girl for kitten. But while the play life of the kitten is intense, comparatively speaking, it is of short duration. What the cat learns for his life's business he must learn quickly, for infancy with him passes rapidly; he will be a full-grown cat in one year. And now we come to a fundamental fact, and one of tremendous significance in all animal life. The higher in the scale of animal life, the longer is the relative period of infancy. Consequently the higher animals have a longer period in which to acquire their education, and therefore a longer period in which play is the dominating activity. In discussing this question, Professor Groos, in his interesting book on the *Play of Man*, says, "Infancy is for play." In this statement he implies that education in infancy is acquired largely through an actuating impulse to learn through play. Of course to the child the satisfaction of this instinct is all the excuse that he requires to warrant his activities. He is unconscious of the value of play, and thus he develops his powers without knowing it. To him play is that kind of work that is suited to the desires of childish ideals and childish impulses.

Physical Development through Play. — If one were to ask in what particulars physical education is acquired through play, one would need to study and analyze a thousand games as Dr. Johnson has done, in order to see what varied demands games make on mind and muscle. A few illustrations must suffice here. If we take the game of baseball as a typical boys' game, it is easy to see in it certain physical demands. It requires a great deal of running, but only for short distances. Thus the larger muscles of the lower limbs and the nervous centers controlling them get abundant exercise without undue fatigue. It requires much throwing of the ball, and this brings into action the fundamental muscles of the arm and shoulder, and all the nerve centers controlling them. Both hands are used in batting and catching, and the eyes are constantly judging distances, the direction that the ball is taking, and the rapidity with which it is traveling. Such vigorous activity naturally increases the circulation of the blood and gives the heart its needed strength through exercise. Deep breathing is demanded and the lung capacity expands. The large muscles of the trunk are strengthened in batting, stooping, and swerving, and, in short, the whole fundamental muscular system and the brain centers in control are brought into normal activity. Best of all, the muscles and centers thus trained are just those upon which life's demands fall most heavily, and hence a fundamental preparation for useful activity is taking place.

Gymnastic Exercises and Play Contrasted. — Many systems of gymnastics fail for normal individuals, because they develop some parts of the body out of proportion to the legitimate needs of life. Certain series of exercises are devised, many of which demand the development of muscles beyond the relative usefulness of those muscles to real life. Because gymnastic drills or exercises will make certain muscles stand out in an unnatural, or at least in an unusual, way, it is evident that such exercises are not duly coördinated with natural needs.

FIG. 2.—OPEN-AIR GYMNASIUM

Did *you* ever "skin a cat"? Why? (Courtesy Mr C. B. J. Snyder, New York.)

If, for example, certain games throw such large demands on the heart that it develops out of proportion to the normal needs of everyday life, it is evident that such games may, if continued for a season, do far more harm than good. A heart so developed is a menace to health when these particular games are dropped and milder games or ordinary labor takes their place. Degeneration of the heart may then set in, and serious complications may ensue. This is one reason why long-distance runners and long-term football players frequently die in later life from heart failure. But it is truly wonderful how the nonprofessionalized games, those that are dearest to a boy's heart, minister to an all-round physical development consonant with the demands of what we may term normal activity and normal living. There are games, such as marbles and tops, which demand skillful coördination of the accessory muscles of hand and eye. Others lead to constructive ability, the making of kites, wagons, or bows and arrows; still others, such as playing soldier and riding stick horses, develop poise and balance. These are only suggestions of the tremendous educational effectiveness of games.

The Value of Studying Games. — No better advice could be given to a teacher who is seeking more opportunity for play for her pupils than this: select a half dozen of the most common games that boys delight in playing, study what the boys must learn to do to play them well, and then ask yourself the questions, "Are these powers in need of development? and are they being trained properly for useful labor in the common demands of life?" Of course no fine-spun theories of education ought to emerge from such a study, but a new and fundamental point of view may be reached, and games may be lifted out of the region of things to be endured, into the realm of educational necessities.

The Socializing Function of Games. — Thus far, our consideration of games has had to do with the physical development of the individual; but games are socializing agencies of

superlative importance. Baseball requires teamwork, and demands coöperation and subordination. Each player is responsible for a share in the final success or failure of the "team." Each must be ready, therefore, to respond, must watch the whole game, judge of the strength or weakness of each member, and learn to abide by a decision even though, in the heat of excitement, a mistake has been made. No more democratic game could be devised than baseball, for he is the hero, whether rich or poor, who can hit the hardest, run the fastest, and catch the ball most surely. Here, even the boy who is dull in his lessons may have his chance to shine, may save the game, and may win that recognition from his fellows that is dear to all boys. It is fatal to ambition and disastrous to any life to be able to surpass in nothing. The more our boys learn to play together, the more surely will they be able to work together.

Girls' Games. — But the girls like to play, and they need to play as well as the boys. It is characteristic of most educational literature, however, to illustrate points by referring to boys and their doings. This show of partiality is doubtless due to the fact that it is only in recent times, and especially in our country, that girls have had anything like an equal chance with the boys. Girls' games reveal girl nature just as clearly as boys' games reveal boy nature. Girls romp and squeal, they jump the rope, play at housekeeping, play with dolls, put on long dresses and play at being ladies, and, in general, do not care for the more violent games of running or jumping. Hopscotch has, however, been a girls' game since the days of Cæsar, and probably long before. Dolls have been found in the excavations of the oldest cities of the world, and some form of "Ring around Rosy" is as old as civilization. Some features of girls' games deserve more careful study and discussion than may be entered upon here. Suffice it to say that nature here again leads unconsciously toward a normal preparation for life through the games that the instincts demand. Few

girls delight in ball, for their life-needs have not developed power of shoulder and arms to succeed in such a game. It is clearly Nature's plan that a woman should not be as strong of arm and shoulder as a man, and any game or labor that would impose this unnecessary strength is foreign to the needs of the life of women. Even if women have been the burden carriers of the uncivilized tribes, it has been an imposition forced upon them by those with stronger arms. Girls' games are more individualistic than boys', and yet they, in the main, demand a social setting. "It is lots more fun" to play housekeeping where neighbors are accessible, and where much visiting and comparison of domestic equipments are possible, than otherwise. It brings much keener delight to a girl who puts on a long skirt, in play, if her display can be made in the presence of her companions. It would rob the making of dolls' dresses of its chief delight, were there no competition and comparisons in sight. Even the more vigorous games of basket ball and tennis, which some girls enjoy, and from which much physical education may come, derive a large part of their pleasure from the consciousness of the uniforms or suits usually worn in these contests. However, this suggestion must not be carried too far. Well-developed, vigorous girls, those whose superabundant energies demand release, often get the same kind of physical joy from vigorous exercise as boys, and it would certainly be of great advantage to our girls if this phase of their lives received more attention and consideration. It required a great deal of self-denial on the part of the Athenians, who contended that women were most womanly when infrequently seen and less frequently heard, to declare that the women of their Spartan rivals were more beautiful than Athenian women, especially since they knew that the Spartan maidens had a freedom that Athens persistently denied her maidens. The Spartans argued that if strong, vigorous children give the only true promise for continued Spartan supremacy, the mothers of such children must be

physically strong and robust. Hence, they trained their girls to take active interest in running, wrestling, swimming, and other such vigorous sports. Their girls grew strong and beautiful as the result of such freedom and physical exertion. It gave them courage, and despite the harsh military discipline of Sparta, they did not lose their motherly instinct or the tenderness associated with it. They were not fastidious, nor timid, nor effeminate in the weaker sense of this word. They were strong of heart and limb, but they were none the less devoted wives and mothers in so far as the stern laws of the state permitted. The freedom granted American girls to play and to be in the open air is much in our favor and will count as a valuable element in the preservation and strengthening of the stamina of our people.

The Moral Significance of Play. — Any sympathetic young man, with a modicum of good sense and ability to handle boys, can break up a " city gang " in a week if you will give him a chance at these boys with a real playground. They will prefer to don a baseball suit and play ball rather than to steal, fight, and torment people. It will take skill and patience at first, for such boys have no play lore ; they will be extremely awkward and each will want to have things go to suit him. But, after all, there is nothing so satisfying to vigorous boy life as play, and nothing will enforce better habits if real success is to be attained. Baseball managers have found that immoral habits of any kind are very costly, and that even a fit of temper will often weaken a man's skill for a day or two. Recently, the authorities of one of our state's prisons has discovered that with the introduction of baseball into the daily round of prison life, rules are more readily obeyed, and prison discipline is rendered far easier and safer.

Four years ago, in a paper prepared for the Second Annual Congress of the Playground Association of America held in New York City, Mr. Allen Burns successfully maintained the thesis that, " The presence of parks and playgrounds in a

FIG 3 — A playground furnished by a manufacturing establishment for the children of its employees. An expression of a new sort of civic righteousness (Courtesy Playground Association of America.)

FIG 4 — Learning to manage themselves without a "boss." (Courtesy Playground Association of America.)

neighborhood is coincident with a decrease in the number of cases of juvenile delinquency, and with an increase in the proportion of cases successfully cared for by the courts." His arguments and conclusions were based on facts gathered in Chicago in congested districts. In summing up his conclusion with reference to small parks, such as those on the South Side of Chicago, he declared, "A small park can be expected to be coincident with a decrease of delinquency, within a radius of one half mile, of 28.5 per cent, conditions of the neighborhood in other respects remaining the same. To provide a probation district with adequate play facilities is coincident with a reduction in delinquency of from 28 per cent to 70 per cent, or 44 per cent as an average." Put in a different way, this means that nearly half of the meanness punishable by the courts would cease if bad boys had a good playground within half a mile of their homes and they were allowed the privilege of using it. What would happen if there were playgrounds within two blocks of their homes? We can only conjecture. If boys can chase each other in a real game, they are not likely to throw stones at a peddler in order to get him to chase them. If a boy learns that smoking cigarettes will make it impossible for him to run well in foot races, or to throw a curved ball successfully, he will be the more willing on this account to stop this evil habit, provided, of course, that he has had an opportunity to experience the delightful tang of these games. If a boy grows up without a chance to play games, he will lose his desire to do so, and then his superabundant energy is likely to lead to immoral excesses.

The Danger due to Degeneracy. — There are some lessons in biology that everybody ought to know, because they have to do with human life in every stage of its existence and with every class of persons. The germ of human life is continuous and is modifiable through experience, if this word may be used in its broadest sense. In other words, the child repre-

sents one stage in life, with the modifications that the germinal cells have undergone directly or indirectly from the first. This life principle may increase in vigor, or it may degenerate. If a degenerate cell from a weakling father is nourished by a degenerate mother, the resultant weak and degenerate child is a natural product. Teachers must come to see that they are not simply dealing with individual children for their own sakes, but they must have in mind future generations. Degeneration does not imply visible bodily infirmities alone, but also loss of vigor, and increased instability of the nervous system. The great importance of eugenics (the science of being well born) is beginning to appeal to the world with a new emphasis, and the general truth that it is of tremendous significance to be born of good stock and of virile parents means more to-day than ever before.

Along with this general truth, merely suggested, goes another of at least equal importance. The individual life is capable of increasing its inherited strength or weakness. For a child who is so unfortunate as to be born of weaklings much may be done to offset in a measure such natal influences. True, it may take generations to revivify his descendants, but to make no attempt to reform such conditions would at once mark the beginning of a steadily increasing degeneracy. Normal free play, coupled with such gymnastic exercises as individual children may need, looks toward the preservation of health and sanity, and that reinvigoration of human society dependent on good health, strong bodies, and virility.

The Need of Larger Playgrounds. — The above brief suggestions have not in the least overestimated nor exaggerated the great educational values to be derived from play. But the questions that will arise in the minds of all thoughtful teachers, especially those in cities, are these: Why do we not make more of this powerful self-initiation on the part of the children? Why do we not furnish the children with adequate playgrounds, adequate time to play? and why do we not

utilize the play impulse to a greater degree in teaching them the ordinary branches listed in the course of study? No one can answer these questions with complete satisfaction; but there are certain reasons that may be understood and stated simply. In the first place, it is much easier to manage and direct a class of children seated in a schoolroom than it would be to manage them where freedom is allowed. It is practically impossible for one teacher to handle more than a third as many children where the play spirit enters into the work as teachers are required to manage and teach in the ordinary way. Hence, we are sacrificing the more natural method of dealing with them for the sake of economy. In the next place, the teacher's interest lies chiefly in intellectual short cuts to intellectual programs. In other words, teachers are more interested in the adult point of view than in the child point of view. This is a natural result of learning and of adult life. It is only the rare teacher who can be a scholar and at the same time retain that sympathetic attitude toward childhood's desires and needs, that is essential for the greatest success in teaching primary or elementary classes. Jacotot, the eminent French educational reformer, saw this fact clearly, and went so far as to say that it would be better for children to have young unlearned teachers, for then these could make progress together with the children, and would consequently more nearly meet the desires of their pupils and appreciate their point of view, than older and more scholarly teachers.

In the third place, we have failed to make use of the play spirit as we should, because of the congregation of the people into large cities. There land is expensive, and here again economy of a false sort sacrifices the needs of childhood for the sake of adult ideals and modern luxury. Not since the days of the ancient Greeks have children in cities been decently cared for in this respect. And even in the country, were it not for the outdoor life that children naturally lead, there would be little relative difference. I have just made a

survey of more than twelve hundred rural schools in nineteen different states, and have found that less than 15 per cent of them are furnished *with playgrounds large enough to enable the children to play with any degree of freedom and vigor.* It is a national habit, fixed through three hundred years or more, to neglect to supply adequate playgrounds for our school children; and this is true even in the country where land is cheap, as well as in cities where land is so expensive. No one can justify this policy of neglect, and no one can explain it save through the ignorance or avarice of older people.

Failure to provide for Playgrounds. — There was a time in our earlier history when a large percentage of our people lived in rural homes. Such cities as then existed were not congested, and there were open spaces and "commons" at no great distance from the children. The villages and towns were not lacking in opportunity for outdoor games, both in winter and in summer. Besides, the open country was close at hand, where hunting, fishing, and playing Indian were common sports. Conditions have greatly changed. No city in this country has a tithe of the playgrounds that it should have, despite recent strenuous efforts in this direction on the part of a few of the great cities. The number of children in one block in parts of large cities is large enough to require ten acres of ground for free, unobstructed play. And these are the children most in need of play. It is manifestly impossible to make a great modern city a suitable, or even a permissible, place in which to rear children, especially the children of the poor. Despite all that has been done, — and some of our cities have done wonderful things to ameliorate conditions, — any one who knows the real situation knows that the task to establish *ample* playgrounds within our cities is altogether hopeless. If our cities continue to grow at the rate at which they are now growing, what has been done will count for even less than it does at present.

City Schools removed to the Country. — I see only one ray

of hope for the children of great cities. Either this instinct for play must be starved, or else our school buildings must be removed from the cities to the adjacent open country where playgrounds may be had, and the children daily transported to and from school. Here they would be free from the noise, dirt, and danger of a great city for the school day. Here, they could breathe fresh air, have a chance to play, come in contact with grass, and flowers, and trees, and their horizon would not be limited by brick walls and narrow streets. This plan may seem visionary, but it must come, for we dare not permit the children to develop tendencies toward anarchy and rebellion.

Playgrounds in the Country. — Strange to say, the district schools in the open country have, even with inexpensive land at hand, gone on in the same way. In earlier days, as already suggested, it was easy to find an available playground near the school building, and no one would object to its use. But now the "No trespassing" sign is almost omnipresent both in city and country, and it is very difficult to find in the country a worthy playground to which the children may have unstinted access. One of the greatest needs of the country school, especially those in places where several districts have consolidated in order to secure better classification and better teaching, is just this one of larger grounds. Those boys who have left school to work on the farm, as well as those who are still in school, need opportunity for games with their fellows. There is no other opportunity offered in country life that may be made so effective in socializing, unifying and satisfying the spirit of boyhood, as vigorous play with his fellows. Each playground should provide room for a baseball diamond of regulation size. Schoolhouses and school grounds are the common possessions of the community as a whole, and their use should not be limited to those who attend school. All the boys and men in the neighborhood ought to feel that they have a right to use the school grounds, and even the school-

house in any legitimate public way when school is not in session. Can you think of anything that would do more toward breaking up the habit of going to town every Saturday than a match game on the school grounds between rival neighborhood teams? Any one who has imagination and faith in boy life can fill in the outlines here suggested for making country life more enjoyable and satisfying to the lads whose safety and usefulness consist largely in staying on the farm.

Work and Play. — The emphasis thus placed on the value of play and playgrounds must not be so construed as to lead to the assumption that play can take the place of work. Nothing can be farther from the truth. Teachers and parents who do not teach the children under their control to work diligently, even to the point of normal fatigue, are doing them a serious injury. When work and play are properly proportioned, each goes better and each brings more joy. Children can play too much and work too little; or work too much and play too little. Wise guidance is necessary in reaching that golden mean where the spirit responds with readiness to the demands of labor, and with equal delight to the opportunities for play. After play there should always follow a period of quiet intense work of a tranquilizing sort. Self-control and poise are much more easily acquired under such conditions than at a time when the body is restless with a superabundant supply of energy.

TOPICS FOR INVESTIGATION

1. Make a careful study of the educational value of the games that your pupils like to play, and then determine, if possible, why these games have persisted so long and are the source of so much perennial delight.

2. Why do city children need so much supervision in their games?

3. Determine if you can why, in general, free games in the open air are so much preferred by children to directed exercises in gymnasiums.

4. What is the effect on the normal character of both girls and boys who have been given no chance and no opportunities for playing with other children?

5. How may the problem of larger playgrounds for city children be most easily and intelligently solved?

6. Study the relation of juvenile crime to the facilities and opportunities for wholesome play in the cities.

7. What do you think of the moral influence on our young men, and even on the older ones, of what has been termed our national game, baseball?

8. *How far should the churches and other religious and moral institutions coöperate with educational workers to secure playgrounds and opportunity for play to all normal children?*

9. How may organized play and recreation centers be provided in rural districts?

10. Why have so many kinds of games been developed by the children, and why do they play them in more or less regular order?

SELECTED REFERENCES

AYERS, L. P. *Statistics of Playgrounds in the Hundred Largest Cities in the United States.* Proc. of Playground Assoc. of America. 1908. pp. 372–386.

BRECKINRIDGE, S., and ABBOT, E. *The Delinquent Child and the Home,* Chap. 9. New York, 1912. 343 pp.

CURTIS, H. S. *The Growth, Present Extent, and Prospects of the Playground Movement in America.* Pedagogical Seminary, v. 16, pp. 344–360.

GALBRAITH, ANNA M. *Personal Hygiene and Physical Training for Women.* Philadelphia, 1911. 371 pp., illus.

GROOS, KARL. *Play of Animals.* New York, 1898. 341 pp.

GROOS, KARL. *Play of Man.* New York, 1901. 412 pp.

GULICK, L. H. *The Healthful Art of Dancing.* New York, 1910. 273 pp.

HARRIS, W. T. *Recess.* U. S. Bureau of Education, Circular of Information. 1884. pp. 59–66.

HILL, LUCILE E. (Editor). *Athletics and Out-of-door Sports for Women.* 1903. 339 pp., illus.

JOHNSON, G. E. *Education by Plays and Games.* New York, 1907. 234 pp., illus.

LELAND, A. L. and L. H. *Playground Technique and Playcraft,* Vol. I. 1909. 284 pp.

MAHAFFY, J. P. *Old Greek Education.* 1882. 143 pp.

MERO, E. B. *American Playgrounds.* Boston, 1908. 270 pp., illus.

SARGENT, DUDLEY A. *Physical Education.* Boston, 1906. 311 pp.

CHAPTER III

LOCATION AND CONSTRUCTION OF SCHOOL BUILDINGS

Location of School Buildings. — In the previous chapter, emphasis was placed on the need and value of playgrounds, and it was proved that no location should be selected for a school building where ample facilities for play could not be furnished. But there are many other considerations of importance that should be taken into account before selecting a site for a school building, for it must be held in mind constantly that after a school building has once been constructed on a given piece of ground, it is not likely that any change will be made for many years to come. Hence, a great many difficulties may be avoided by being especially careful in the matter of location.

Location of the Building with Reference to the Convenience of the Children to be Served. — Other things equal, it is of course important that a school building should be located so as to be most convenient to all the children in the district, whether this be in town or in the country. If the population were equally distributed, land values the same, and hygienic conditions favorable, naturally the center of the district would be the logical place for the location of the building. But it rarely happens that other things are equal, and that the center of the district is the best place for its location. In country districts it may happen that the center of a school district is not the center of population, and this may necessitate the selection of a site more convenient to all concerned. In cities, this point is of less importance because the distance to be traversed is not so great. Country people are very jealous with regard to the matter of the location of their schools, and will frequently insist on having a building placed

in the center of the district, even if that point is altogether unfit for a school site. School trustees and teachers, as well as county superintendents, have probably had more trouble in settling disputes on this question of location than on any other connected with the organization and management of

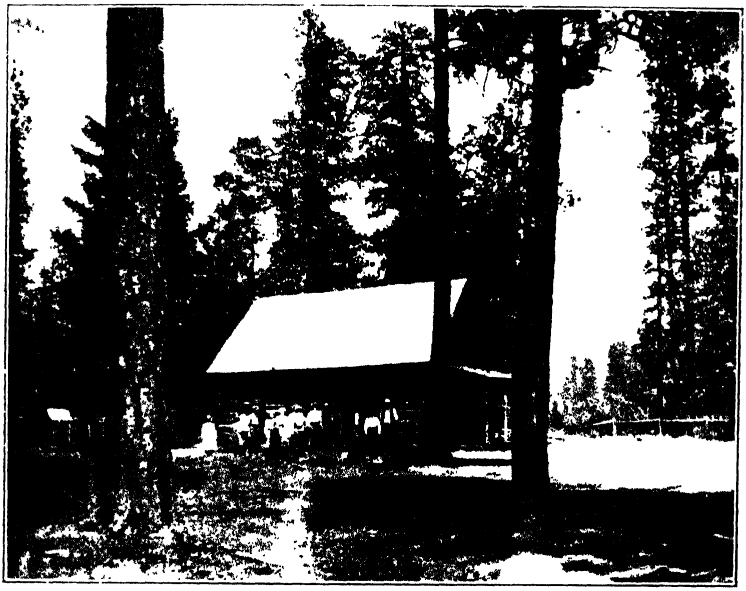


FIG. 5. — A primitive schoolhouse one hundred and twenty-five miles from a railroad in the mountains of California. The teacher is a well trained college graduate. If boys had a chance to select between such a school, even though poorly lighted, but so beautifully situated, and one in a "cañon" of Chicago, can you doubt which they would choose, or which would be the more wholesome?

country schools. There are certain general facts with regard to the location of a school building that ought to be considered, and which will apply, in the main, both in the case of country and of city schools.

Soils. — The importance of selecting the proper kind of soil upon which to construct a school building is greater than is commonly supposed. A soil that has been contaminated with

the intermixture of much decomposing animal and vegetable matter is not a safe location either for a dwelling house or for a schoolhouse. The air, because of the tremendous pressure exerted on it, sinks into the ground to the depth of many feet. The bacteria within the soil will, in the presence of oxygen, moisture, and warmth, attack the animal and vegetable matter therein found, and, as a result, release a great deal of carbon dioxide and other noxious gases. Hence, it happens that the ground air is much more impure than the air above ground, and this impurity increases with the amount of decaying matter in the soil. If, therefore, a schoolhouse is constructed on such soil, the air about the schoolhouse will become more or less impure as a result of the outflow of this ground air. The earth is breathing, as it were, for during the day the air above ground, especially in warm weather, is at a higher temperature than that beneath the soil, while at night or in cold weather the opposite is true; hence, the warmer air in the ground, being lighter, will rise at night, and the cold air from the outside will take its place. This accounts, in large part, for the cellar-like odor often found in basements and in rooms on the ground floor when the building is opened in the morning. While this noxious air arising from the ground does not have a very large influence upon the atmosphere of the school during the day, it may have and does have at times an influence sufficiently great to warrant us in guarding against it. A porous soil that has not been contaminated will naturally permit the air to enter into it more deeply, and will be kept pure much more easily than a soil that is not so porous, and hence retains its impurities longer and offers more continuous trouble. It not infrequently happens that vacant lots in towns and villages have been used as dumping grounds for all sorts of refuse, and are later utilized as sites for dwellings or public buildings. In case it becomes necessary to use such a site for a school building, the only safe thing to do is to cart away the contaminated soil

and to replace it with pure, sandy or gravelly loam. Such soil not only purifies itself quickly, but permits the moisture to sink away rapidly, and hence offers a better site for playgrounds, gardening, and agricultural work.

This ground air is not only troublesome from the point of view of the impurities that it carries, but it may be saturated with moisture gathered from the ground, and if it is permitted to rise into the building, especially at night, it will cause the blackboards to sweat, will mar the furniture, warp the floors, cause the wood in the building to decay, and will introduce various other unhygienic conditions. In general, the moisture introduced through the ground air is a much more serious consideration than the deleterious gases introduced into the schoolroom. It is important, therefore, to select a school location with good, permeable soil which has not been contaminated in any way, and which will render the playground more accessible and usable.

The Drainage of School Grounds. — A school site should be higher than the contiguous ground about it, in order to avoid surface drainage toward it. This does not mean that school buildings should be placed on a hill, to be swept by cold winds, or removed from ground that may be utilized for games, but it is mentioned simply to call attention to the fact that any outlying, infected ground, higher than the site upon which the school building is to be located, may bring toward it, either on the surface or below the ground, foul germ-laden water to such an extent as to contaminate the ground all about the building and to render it unfit for use. It may often happen, however, that, in a flat country, it will not be possible to select a site that will meet all these requirements. If a level plot of land must be selected, and even one that is likely to be damp a part of the year, such a site can be rendered fit for a school building if proper precautions are taken with reference to drainage. In all cases where the soil is in danger, from any cause, of becoming water-soaked, and where

the water level approaches too near the surface of the ground, tile drains should be placed all around the building and, if necessary, should be radiated through the playground. This, of course, will be possible only where a convenient outlet for such drains can be found. If the ordinary earthen tile, such as farmers use for draining land, be placed well below the level of the footing of the foundation and the basement floor, and opened into a safe drainage at a reasonable distance from the building, it will bring great relief from the deleterious ground air as well as from the moisture associated with it. This drain may be placed five or six feet from the walls of the building in order to intercept and carry away any underground flow of water toward the building. The water that ordinarily enters such drains comes up from the bottom of the ditch, and is due to the pressure of the water in the surrounding soil; hence, by joining the tiles at the top, and leaving them slightly separated at the bottom, the water easily gets into the drain and runs away. The best drain tiles are made so as to meet these requirements. For the reason just stated, it is not necessary to cover the tile with broken stone or porous material. The water will find its way into the tile from below.

Need of Gutters below the Eaves. — It is a serious error to allow the rain water from the roof to pour down all around the building, or in one or two places through leaders from the eaves troughs. The water shed from the roof should not be allowed to soak the ground around the building, for this would keep the walls damp and cold and altogether insanitary. If a drain is placed about the building as indicated, the water from the roof may be conducted down to the tile, from the eaves troughs and leaders, through cemented sewer tile, and carried off along with the underground water. In this case, it is necessary to keep the roof clean, or to trap the water before it reaches the drain, in order to prevent débris from clogging the tiles. If no drain is laid so that the water line is not kept below the basement floor, then the water from the roof should

be carried a safe distance from the building in sewer tiles, well cemented together, and discharged where it cannot flow back toward the house. It is highly advisable wherever the ground is likely to be wet to take the precaution of thorough draining as suggested. This is not an expensive undertaking, for with a little supervision an ordinary workman can lay the tiles properly, and a good drain will last longer than the building.

Freedom from Noise and Dust. — In towns and cities, it is of very great importance to select a location for school buildings away from all noisy railroads, heavy traffic, and busy factories. This fact is becoming more and more important as our cities grow in size and the amount of traffic continues to increase. To one who has not had experience in school work, this may seem a comparatively insignificant matter; but it is only necessary for any one who is anxious to give the children a proper chance to consider briefly the serious troubles growing out of disturbing noises. It may be said that children soon get used to these noises and neglect them. They may, indeed, become unconscious of a great deal of the disturbance that fills the air in a modern town, but their nervous systems are nevertheless being wrought upon even though they are unconscious of it. A school building located beside a busy street is an impossible place for the quiet and undisturbed study that proper health conditions demand. There are many school buildings in this country so located that a recitation cannot be carried on in the proper way. The teachers and pupils either have to speak in an uncommonly loud tone, or else they must wait until a noisy wagon or a rattling car passes. As a result of some investigations made several years ago, I found that in one school building, half a block from a very noisy and busy railway, the children lost at least one fifth of the time of the average recitation. It was often impossible to carry on the recitation until the train had passed. Considered merely from the point of view of economy, that

was a very wasteful procedure. But this was not the worst feature of it. The children are necessarily disturbed by such noises, and the fatigue of the day is much greater than it would be if they were not assailed by all this din and rattle about them. I was told recently by the principal of one of the great high schools of this country, that, because those who were in authority had located a school building in the busy, noisy part of the city, it would become necessary either to condemn one or more of the streets passing this building, or to abandon the use of the building for school purposes. I want to urge teachers, therefore, to do all within their power to influence boards of education, and those whose duty it is to locate school buildings, to seek out a quiet place, away from railways, noisy factories, and busy thoroughfares.

Tall Buildings and Other Obstructions to Light. — It is not only becoming more and more a serious problem to find space large enough for school grounds in cities, but it is also coming to be almost impossible to find a place where tall buildings do not obstruct the light. The horizon line even from the second story of city school buildings is often so high that on dark days artificial light must be used, and in the rooms on the first floor where the smaller children are best accommodated, the question of supplying sufficient light is one of prime importance. No rule can be given that would apply in all cases, but it is safe to say that under good conditions and in climates where light is abundant, no building should be constructed nearer a school building than a distance equal to twice its height. That is to say, when a school site is selected in cities, either grounds sufficiently large to insure no breach of this rule must be chosen, or else some restriction designed to meet this requirement must be placed on the erection of tall buildings in the vicinity.

In the country, a site near a high hill, mountain, or tall forest trees may introduce the same difficulty with reference to proper lighting. In mountainous regions, it is not easy at all times

to find a location that is free from the difficulties here suggested. If a school building must be located where the available light is thus diminished, special care must be taken in setting the windows, and in allowing more glass surface than would ordinarily be required.

School Buildings should be removed a Safe Distance from Inflammable Structures. — There is comparatively little danger from loss of life by fire in well-constructed school buildings of two stories in height — and none should be taller — when due effort has been made to eliminate the chances of possible fires within the building. The modern methods of fire-proofing buildings, together with fire drills, emergency doors, and other precautions, have rendered school buildings reasonably safe, and it is now only necessary to guard against fire from without to insure not only the safety of the pupils but of the building also. Fire escapes for school buildings are, in the main, a delusion and a snare.

Objectionable Factories and Other Offensive Business Houses. — It seems almost useless to call attention to the fact that school children should not be gathered into a school building located in a neighborhood where abattoirs, livery stables, fish markets, or any sort of a factory can contaminate the air with offensive odors. But in many cities, school buildings are found with such environments, and it will require much education of the public to control effectively such conditions. In country districts, these conditions rarely prevail, and yet even there school buildings must be kept at a safe distance from stagnant ponds and ill-kept barnyards.

Saloons and Other Immoral Places. — Here, again, cities are subject to difficulties from which the country is usually free. It has become necessary in many cities to pass and enforce ordinances prohibiting saloons from territory adjacent to public schools. But these ordinances are not always enforced even after they have been enacted. I have actually known of a school board that rented rooms directly over a public drinking

house, and compelled teachers and pupils to occupy them. Such liberties with the moral standards of public schools are, however, rare, and usually the very men who frequent saloons will, when appealed to properly, help to uphold the authorities when they seek to keep the neighborhood surrounding school buildings free from the suggestions and liberties associated with such places.

Basements in School Buildings. — It is a well-nigh universal custom to construct basements under city school buildings, and country schools are now beginning to take advantage of this means of securing space for fuel, heating appliances, and toilet fixtures. There are certain sanitary advantages to be derived from a properly constructed basement that deserve some brief consideration.

Location of Heating Plant. — In all cases where a small or medium-sized building is to be furnished with heat from a single boiler or furnace, it is far more convenient and usually more economical to locate such appliances within the building than outside under a separate roof. If the medium of heat is warmed fresh air, hot water, or low-pressure steam, there is much to be gained by placing the heater, when possible, directly below the rooms to be heated. Such location insures more direct delivery of the heat to the various parts of the building, and in the case of furnace heat, through decreased friction in air ducts, an increased supply of air furnished at a given temperature. In the case of hot water or steam heat, the return to the boiler may be made easier, and heat is thereby more uniformly delivered to all parts of the building. In most cases, the added length of flue or chimney insures better draft, and consequently more complete combustion of fuel. Basements afford opportunity for the storage of fuel convenient to fires, and of reducing the trouble due to dust and dirt almost invariably associated with coal or wood.

Economy of Basement Rooms. — Ordinarily a given amount of room in a basement is not so expensive as it is above ground,

for foundation walls may serve not only as supports for the structure above ground, but as walls for the basement rooms. Where the soil is of such a nature as to require small expense for excavation and proper drainage, useful space may be secured at a comparatively small cost.

These facts are mentioned with the hope that those who have to do with the construction of rural schoolhouses will find it within their power to give more serious consideration to the construction of basements in connection with such buildings.

Basements may prevent Ground Air from entering the Building. — A well-constructed and well-ventilated basement will shield the building from the rise of moisture and the entrance of unwholesome ground air. In order to accomplish these ends, basement walls must be made of a good quality of concrete or vitrified brick, the floor carefully covered with cement or asphaltum, and if the location demands, a tile drain laid all around the building to carry off the ground water and to guard against the saturation of the soil by heavy rains. In wet, cold weather, when warm rooms above serve to create an exhaust movement of the air from below, and the pressure of the water into the ground all about a building drives the ground air toward this drier spot, properly constructed basements are most useful in preventing the contamination of air in the rooms above.

Play Rooms in School Basements. — It is never advisable to use basements as play rooms, unless there are no playgrounds, or bad weather prevents outdoor games. When basements are dry, well guarded against ground air, get plenty of light and good ventilation, there can be little objection to the use of such rooms during inclement weather, especially for gymnastic exercises and those directed games that require vigorous exercise.

Lavatories and Toilets in Basements. — Basements furnish convenient places for the location of lavatories, baths, toilets, and the necessary plumbing fixtures needed in connection with a system of water supply. In cold climates toilets should

be within the building in order to save the children from useless exposure, and to guard the toilets from negligence. In fact, these necessities may often be more safely placed within the building than outside, for when removed from the building, they are usually allowed, through sheer neglect, to become insanitary and a menace to both health and morals. Finally, basements prevent much trouble in cold climates by eliminating accidents due to freezing weather. When washout toilets are located above ground, unless buildings are kept warm at all times through the winter, the pipes are likely to burst, and serious inconvenience and expense will ensue.

Basement rooms should be at least ten feet from floor to ceiling, well lighted, heated, ventilated, and thoroughly guarded against the influx of ground water. Further discussion of toilet sanitation and baths will be given in separate sections. (See pp. 118 f. and 98 f.)

Manual Training Rooms in Basements. — If basement rooms are well lighted, well ventilated, and rendered pure by the entrance of direct sunlight, they may be safely used for manual training rooms, especially for work in wood and iron. Such work, however, demands good light, and rooms that are dry and airy. Where conditions permit, it is better to arrange rooms above ground for this work, but it is well worth while to utilize a basement for this purpose when no better place can be secured. Generally speaking, it is not advisable to locate workrooms for girls in basements, for sewing, cooking and other lines of domestic training require more light, heat, and ventilation than the ordinary basements afford. Rooms for such work, especially where gas or electricity may be utilized for cooking, are more sanitary if they are located above ground, and even in the second story of two-story buildings.

THE CLASSROOM. — The Classroom the Unit of Schoolhouse Construction. — The main work of a school is done in the classroom, and at least three fourths of the time of the children during school hours is spent in the classroom. It is

of primary importance, therefore, to construct and to equip these rooms in such a way as to make them sanitary, attractive, and well adapted to their purpose.

Size of a Classroom. — It has frequently been said that at least twenty square feet of floor surface should be supplied to each child in attendance upon our public schools; but theory and practice in this regard, as in most other rules for the proper care of children, are far apart.

No teacher should attempt to teach fifty children, for she cannot divide her time among so many and do good teaching. One way to limit this overburdening of the teacher and the neglect of the individual child is to lessen the size of the schoolroom so as to accommodate fewer pupils. The system of single desks, adopted rather universally in town and city schools, also helps to prevent overcrowding. But these methods of limiting numbers are only devices and are often overruled by those in authority. There are, however, some fundamental considerations with reference to the size of classrooms that all teachers ought to keep in mind, not only for the sake of the advice that they may give to school officers, but also for the sake of the management of their classes.

Length of a Classroom. — The length of a classroom should be determined by (*a*) the distance that the ordinary speaking voice of the teacher will carry clearly and distinctly. No argument is necessary to establish the truth of this statement, for the voice of the teacher plays a large part in teaching and managing her pupils. A pupil seated in the rear of a classroom ought to be able to hear distinctly and without effort all that the teacher expects him to hear. If, for example, a pupil fails to get the exact pronunciation of a word or syllable, he cannot learn to spell so easily and correctly, and he will unconsciously permit himself to become careless in his own pronunciation. It is very tiresome to have to make an effort to hear accurately, and no child will continue the attempt for any length of time. More than three fourths of all the teachers

in this country are women. Their voices are usually untrained in matters of careful enunciation and the quality of their tones is rarely such as to render their voices most effective in carrying power. In the main, they have weak voices, and through much talking they are likely to strain them and make their tones strident and impure. A classroom that requires that some of the children be seated too far away to hear easily what the teacher says is harmful to both teacher and pupils.

(*b*) The length of the schoolroom must be such that the teacher will be able to hear the children distinctly when they speak in an easy, natural way. At best, schoolroom air is hard on the throat of the child, especially if the building is not kept comparatively free from dust and the numerous bacteria that find lodgment on this dust. Besides, it is of great importance to teach children to use their voices easily and effectively in moderate tones, and the lack of this art is quite noticeable in most Americans. Generally, our people enunciate indistinctly, vocalize without painstaking discrimination, and take little pride in elegant, refined speech. Our classrooms must be adjusted to suit these needs, and in the lower grades, especially, there must be no forcing in vocalization.

(*c*) All experienced teachers know that school management is much easier when the children are not far removed from the teacher. While this consideration has little to do in a direct way with health conditions, it may be a disturbing element in an indirect way. A badly governed school cannot be completely healthful. Annoyances and vexations waste much nervous energy, kill interest, and in every way unsettle the mind for hygienic and economic learning.

(*d*) A vital consideration is that which has to do with the distance at which children can see maps, charts, and written work upon the blackboard. Older persons see most of what is presented to them at a glance; that is, they see with their minds more than with their eyes. Children have to see clearly with their eyes before they can learn to see very much with

their minds. It has been demonstrated by careful experimentation that the distance at which the normal eye of a child can see the ordinary writing on a blackboard, without undue effort, is about twenty-nine feet. Beyond this distance, the pupil will either begin to feel the strain of accommodation, or else the work displayed on the board will have to be written with unusually large and heavy strokes.

As remarked above, most of our teachers are women, and their writing is rarely heavy, and frequently small and rather angular in character. Maps and charts, as usually printed, demand a greater allowance in this matter than blackboard work.

Taking all these demands into consideration, it is safe to say that no classroom for children of the elementary grades should exceed thirty-two feet in length, and this length is too great unless an aisle at least two and one half feet wide is left behind the last row of desks. When the hoped-for time comes that thirty pupils will be the maximum number that any teacher will be asked to handle, then the standard length of the classroom ought not to be over twenty-eight feet.

Width of a Classroom. — The proper width of a classroom is largely determined by the requirements for abundant light and the hygienic demands for unilateral lighting. Were it not for these two important considerations, one could readily see that a square room would give the teacher the best opportunity to gather her pupils more closely about her, and consequently manage and teach them most effectively. But this would introduce difficulties in lighting. In a separate chapter the question of lighting will be considered more carefully, and it is only necessary to say here that in climates where sunlight is abundant and the atmosphere clear, a classroom can be properly lighted from one side when the width of the room is not greater than twice the height of the top of the windows from the floor and the combined glass surface not less than one sixth of the area of the floor surface. In northern latitudes,

where the light is dull much of the day, because the path of the sun is far to the south, and where a semi-twilight continues late in the morning and begins early in the afternoon, good illumination cannot be secured in ordinary classrooms whose width is in excess of one and one half times the height of the top of the windows from the floor, other conditions remaining the same.

In Germany the rules generally prescribed for the proper width of a classroom specify that it should not exceed twenty-one feet, and their classrooms are generally higher than ours. We have found in this country that where our schoolrooms are twenty-four feet wide and twelve and one half to thirteen feet high they may be properly lighted from one side, if the windows are correctly placed and the combined area of the glass surface equals at least one fifth, or better one fourth, of the floor surface.

The Height of the Classroom. — In deciding upon the height of the classroom, several factors ought to be taken into consideration. In general, it is a safe rule that no classroom should be more than thirteen feet high, unless for some reason there are obstructions to the proper entrance of plenty of light. It was formerly thought necessary to make classrooms fourteen feet or more in height in order to insure proper ventilation. But we now know that unless the windows extend to within six inches of the ceiling, there is little, if any, gain in securing proper ventilation by making the rooms so high. Any space above the tops of the windows becomes merely a dead air chamber for the warm air, and after the school has been in session for a few minutes, the impurity of the air is about the same in all parts of the room.

In the next place, it will require a great deal more heat to maintain an even temperature in a classroom fourteen feet high than in one twelve and one half feet high. Furthermore, the difference in the temperature between the floor line and the ceiling is generally greater as the height of the room

increases. Hence, if there were no other great advantage in the way of ventilation, this fact alone would warrant school authorities in reducing the height of the room to a minimum of at least twelve and one half or thirteen feet.

Again, every foot added to the height of the classroom adds proportionately to the cost and maintenance of the building. If, for example, a two-story building is to be constructed, by keeping the height of classrooms twelve and one half feet from finished floor to finished ceiling, instead of making them fourteen feet, a saving of the cost of three feet of all the walls of the building is accomplished. This will be no small item, as any one can see. In buildings two or more stories high, stairways are vital units in the construction of the building. It is always more or less difficult to find proper space for stairways, and especially to prevent them from being too steep. Naturally, the lower the classroom, the easier it will be to construct stairways and to lessen their gradients. It will be evident, also, to all thoughtful teachers, that shorter stairways will not only be less expensive, but will be easier to ascend, especially for the older girls. They will also, to some degree, reduce the danger from fire and save time generally.

In this connection, a question will naturally arise in the mind of the reader: "Is a classroom twelve and one half feet high from finished floor to finished ceiling sufficiently high to meet the normal requirements of school conditions?" We have already said that it is better to have windows in one side only, and the question of supplying sufficient glass surface in a wall of this height would naturally arise. In the chapter on "The Lighting of Schoolrooms," this question is answered at length. It is enough to say here that when windows are properly placed and the horizon line is reasonably low, it is not difficult to light a classroom so constructed. From the point of view of actual teaching work, this height is to be preferred to fourteen feet. A room of the latter height is inclined to be resonant and to introduce difficulties with echoes. This is especially marked

when steel laths and hard cement plaster are used. It is much easier, also, to keep a schoolroom clean where the walls are little, if any, higher than the rule given suggests. In rooms of a greater height than twelve and one half feet, where the windows extend to within six inches of the ceiling, there is some advantage in securing better ventilation in warm weather. But considering the question from all points of view, it seems to me we shall err very little, if at all, if we insist that the height of classrooms should not exceed twelve and one half feet, unless some special local conditions demand greater height.

Classrooms in High Schools. — Thus far, I have had in mind classrooms for elementary grades for both country and city. When we come to consider the construction of classrooms for high schools, it is evident that much expense and better results will follow if classrooms are variable in size to suit the number of pupils to be accommodated in any branch of study. It is quite evident that a fourth-year class in Latin in the average American high school will not need as large a room as a corresponding class in English or mathematics. A first-year class in mathematics will also demand a larger room than a corresponding class in German. It would be a needless expense to construct all the classrooms of a high school of a standard size. A decided saving can be made by a careful study of the high school classes and the relative number of pupils attending such classes. Where there is no need for a classroom larger than that necessary to accommodate twenty students, it is poor economy to use a room large enough for thirty-five or forty. With reference to the height of classrooms, there should be little, if any, difference between those for high schools and those for elementary grades. Speaking in general, it is not far from the best practice and sound theory to say, for the elementary grades, wherein as many as forty or forty-five children are to be taught, that the classroom should be thirty-two feet long, twenty-four feet wide, and twelve

and one half feet high in the clear. The height of high school rooms should not be less than twelve and one half feet, but the other dimensions should be determined by the size of classes to be accommodated, but should rarely exceed the dimensions named for classrooms for elementary pupils.

The Floor of the Classroom. — The floors of all schoolrooms should be practically air-tight, deadened, and made of the best material available. Wooden floors are to be preferred to cement or tiled floors, because wood is a poor conductor of heat, while cement or tiled floors are very cold and non-resilient. In wooden buildings where no attempt is made at effective fireproofing, double floors are hygienically necessary, especially in cold climates. Between these floors should be placed some deadening material, such as asbestos, felt, or some prepared deadening quilt, or, if expense must be reduced, a good quality of building paper. In the long run, such deadening material is really economical, for it saves much fuel in winter, and, best of all, it brings relief from cold floors. No part of a school building, unless it be the windows, is more intimately concerned with health conditions than the floors. The upper part of the floor should be made of well-selected oak, maple, or pine boards, not over three inches wide, tongued and grooved, and carefully blindnailed or screwed, so that no crack will open between the boards to catch and hold dust and dirt. Before it is ready for use, a floor must be planed to a level, smooth surface, oiled and waxed, and then kept in good condition. In another chapter ("The Cleaning of Schoolrooms") specific direction for the care of floors will be given.

Teacher's Platform not Needed. — The teacher's platform, like the tower so often found on school buildings, is a remnant from the days when the church dominated schools. It is a direct descendant of the pulpit. The early conception of the business of a teacher required him to furnish all information by means of lectures or sermons, while the pupils were to catch and remember all that they could. To-day we believe that

the best results may be accomplished by helping the children to help themselves. Hence, the chief business of the teacher consists less in lecturing or moralizing than in directing, suggesting, helping, and furnishing opportunity for individual and community initiative. The schoolroom ought to be a workroom, where teacher and students coöperate, and from which *ex cathedra* (*i.e.* from the pulpit) information giving has very largely disappeared. The platform is in the way, makes the building more difficult to keep clean, and has no right in elementary schools. All that is needed for the teacher is a chair and a small desk or table. These may be moved easily to suit demands, and thus it is made possible to utilize the space in front of the desks for special work, such as nature study, sand modeling, or some form of manual exercises. The room is neater, cleaner, and better adapted to school life without a platform than it is with it.

Cloak Rooms. — Each classroom designed for elementary pupils should be supplied with a cloak room, preferably at the teacher's end of the room. In large buildings, especially in cities, this cloak room should open into the classroom only. That is to say, there should be no door from the hall to the cloak room. All who enter the cloak room should first pass through the classroom. This sort of arrangement gives the teacher easy control over the children and prevents much pilfering and disturbance from those who might otherwise gain entrance to the clothing and lunch baskets of the children without entering the schoolroom. By the use of the ventilation plan suggested later (see "Ventilation," p. 155), wraps may be well ventilated and dried and no possible odors from them will enter the classroom. It is important that hooks for wraps, boxes for lunch baskets, and receptacles for umbrellas and overshoes be provided and numbered so that children will be taught to be careful and methodical, and especially that indiscriminate mixing of the clothing may be avoided. Such a provision may prevent the distribution of

parasites or the spread of skin diseases, not to mention the possibilities of more serious contagion.

Doors and Transoms. — It is really remarkable how little change had been made in the construction of doors for hundreds of years until recently. The paneled door with a transom above it is almost universal. But is it best to continue these? At the risk of running counter to the prejudice in favor of panel doors and transoms, I wish to say that I believe that both are out of place in a modern sanitary schoolroom. It is the rarest thing to see a transom in a schoolroom in actual use. It is supposedly put there for the purpose of ventilation, and if not used for this purpose, it certainly is valueless. Transoms serve to catch a wonderful amount of dust and cobwebs, and are rarely cleaned. Even if teachers were inclined to use transoms for ventilation, it is very doubtful whether many of them could be opened. Only in the most carefully and perfectly constructed buildings is there no probability that the settling of the building and the shrinking of the door frames will cause the transom to bind so as to make it very difficult or even impossible to open it. But even if it were usable, it is generally in the wrong place to serve in any way to improve ventilation. If it opens into a hallway, it is not likely that the air from the hall will be desirable for a classroom. If it opens on the opposite side of the room from the windows, and out of doors, then it will serve to create a draft when windows are open, or be ineffective for the whole room when the windows are closed. By lowering all of the windows a little and keeping the transom closed, better ventilation is secured in cold weather. In warm weather, if a draft is grateful and safe, the door can be opened to better advantage.

From the sanitary point of view, balancing the dust-catching proclivities of transoms and the increased expense involved in constructing them against their value as a means to aid in ventilation, there is no doubt in my mind that schoolrooms are better off without them.

Doors without Panels. — What has been said as to the dust that gathers in transoms partly applies to paneled doors. Unless they are dusted daily, the various ledges about the panels will gather dust out of school hours as well as during the school session. When the door is opened or closed, this dust is scattered through the room. Doors are now made without panels, and my experience with them enables me to say that they are not only more sanitary, but more durable, less likely to sag and warp, and more artistic than paneled doors. They are built of a core of light, well-seasoned pine *boards, tongued and grooved and glued together horizontally across the door. This core is then faced with veneer on both* sides with the grain of the wood running vertically with the door. This furnishes a smooth surface on each side, and, when the hardware is in place, gives a finished and artistic appearance. Such a door is strong, comparatively light, and is not inclined to sag or skew. It is easily kept clean, and may be finished on the inside to harmonize with the room, and on the outside with the hall or exterior of the building. "Sanitary" metal doors are also on the market, but with these I have had no experience.

Carpet Strips not needed under Inside Doors. — In this connection, I wish to say that in schoolrooms carpet strips may be dispensed with. They catch dust, are troublesome in sweeping, cause children to stumble, and serve no essential purpose. When door jams are well set, and the doors are so made that they do not sag nor drag on the floor, there is no need of the carpet strips. Exterior doors must, of course, be so set that they will protect against driving rains. All doors to school buildings must be hung to swing outward, especially outside doors. This precaution is necessary to guard against danger from fires. Outside doors in large buildings should be fitted with emergency locks, so that, while they cannot be opened from the outside without a key, they are easily opened by any child from within by a slight pressure against a lever

set directly across the door. Such a device affords protection against thieves while classes are in session, without endangering the children within. These safety locks are made by a number of firms, and although they are somewhat expensive, they ought to be used on the main exits in all large buildings.

BLACKBOARDS. — American teachers make more use of blackboards than do the teachers of any other nation, with the possible exception of England. In Germany, Italy, and France it is quite rare to find any blackboard for the use of the pupils. The teachers of these countries make use of a small blackboard set on a frame something like an easel, and use it for demonstration purposes and for lesson assignments. In this particular, I am sure that American and English teachers have a great advantage. No better training in the democracy of learning can be furnished our school children than the give-and-take criticism afforded by the proper use of a blackboard. If a pupil is called on to solve a problem on the board, and then to stand before his fellow-classmates and explain his work, he learns to do it clearly and correctly in order not to subject himself to class criticism. He learns that if he gives a correct solution and states his reasons for each step clearly, his work — in plain sight of his fellows — will overcome all criticisms. But if he fails, he knows that his weakness is known to the whole class as well as to the teacher. The blackboard may thus teach self-reliance, self-respect, and the necessity of understanding clearly and thoroughly what he undertakes to demonstrate under criticism. And criticism by fellow-pupils is often more efficacious than that by the teacher. The wise use of a blackboard will help to teach all the pupils to respect ability, unassailable reasoning and accuracy.

Best Materials for Blackboards. — The older blackboards were merely blackened boards, as the name indicates, and were either set on a frame, or a part of the ceiled wall was painted black for this purpose. Many rural schools are yet in this stage, and have no other blackboards than those furnished by

sections of painted walls. It is needless to say that such boards are unhygienic and unsatisfactory in many ways. The next step in the evolution of their use, if not their construction, consisted in applying so-called liquid slating to plastered walls. This made a better surface, but rough usage soon caused the plastering to chip, and left the board in a spotty condition. Such a board cannot be washed without endangering the plaster, and must be repainted at frequent intervals in order to prove at all satisfactory.

Slate Blackboards. — Slate was probably used in the more fortunate schools of our country shortly after the blackboard was introduced. There is a table, with a large slab of slate set in the top of it, in the museum of the Antiquarian Society at Worcester, Mass., that is surely over a hundred years old; but it was probably marked more with a pencil, like our old hand slates, than with chalk, though both may have been used. Blackboards were not introduced into this country until about 1810 or 1815, despite the fact that they had already been used for nearly three hundred years in Europe.

A good quality of slate, well set, is still the best blackboard material ordinarily available. It will wear indefinitely, does not, as a rule, glisten and reflect high light, as a painted surface will, is easily washed, takes the chalk readily, and furnishes a pleasing contrast to the chalk marks. It must be kept clean, or it will, in time, absorb oil from the hands and take the chalk unevenly. The high cost of slate has been the chief reason why it has not been used more universally. It is difficult to set evenly and solidly so as to make good joints and prevent the slabs from drawing away from the wall. Where the joints are uneven, they catch the eraser and frequently knock it out of the hand of the pupil, thus scattering chalk dust on the floor and in the air. All teachers know, or ought to know, that chalk dust is hard on the throat, and irritating to the air passages. Every precaution should be taken to prevent it from polluting the air of schoolrooms. The greatest care should be

exercised to match the slabs in setting slate blackboards, in order to get them of the same thickness at the joints, of uniform color, and to fasten them securely to their backing. When these precautions are taken, a good quality of slate makes a blackboard that will meet practically all the requirements of hygiene and utility in a classroom.

Glass Blackboards. — An excellent blackboard may be made of a good quality of heavy glass. It is as yet little used in this country, but is commonly found in English schools. A glass blackboard is prepared in the following way: One surface of the glass is lightly but evenly ground so as to roughen it to cut the crayon. The other side is roughened or left comparatively smooth, and then painted such a color as to meet the most exacting demands of vision. It is then set with the painted side to the wall. The color is thus out of reach of the crayon or brush, and yet seems to be an integral part of the glass, so that a crayon mark stands out in clear relief against a uniform color. Authorities generally concede that a slight tint of dark green mixed with a dead black is the most restful color and does not absorb quite as much light as a pure black. The reader will readily see that glass boards offer an opportunity for securing the best and most uniform color obtainable. They also make it possible to have white or cream-colored blackboards (if such paradoxical designations may be used) for the sake of art work with charcoal or colored crayons. Indeed, it has been claimed that a black mark on a light background is more easily seen than a white mark on a dark background, and it may be that in time light-colored boards, so made, will displace blackboards for all general school work. It is certain that if black crayons could be so prepared as not to soil the hands and clothing and create a general smudgy appearance in the room, there would be little difficulty in making this change. If such boards could be made practicable for daily use, they would bring much relief from the dangers due to absorption of light now chargeable against the ordinary blackboard.

Advantages of Glass Blackboards. — The advantages of glass blackboards over slate, or any other kind now in use, are these: they do not absorb moisture when washed, nor oil from the hands of the pupils; they may be colored to suit the most exacting demands of the hygiene of vision; are practically indestructible; and generally improve with ordinary usage; may be made of even thickness; crayon marks erase easily; and the slabs may be very closely joined together; if painted properly and ground evenly, they reflect no high lights. They do, however, cut the chalk too freely unless very lightly ground. Talc crayons may be used on them to good advantage where light, smooth lines are required. Any skillful mechanic can prepare a plate of glass for a blackboard by the use of dampened emery dust and the proper quality of paint. It is essential in preparing such glass to avoid cutting the surface too deeply and at the same time to render the surface uniform. The task is not easy, however, for it will require much time and painstaking effort to secure a smooth uniform cutting surface. The painting and setting require no more special skill than is required for slate boards.

Manufactured Materials for Blackboards. — There is a great variety of manufactured blackboards now in the market. Some are made of specially prepared sheets of paper or fiber pressed together to the proper thickness, and colored to suit; others are made of various cement combinations, molded and cut in slabs similar to slate; still others are made from a prepared cement, and plastered on the walls. Most, if not all, of these are much less expensive than either natural slate or glass and give fairly good results if properly set, and if the walls upon which they are placed are well protected from moisture. The boards that will prove least satisfactory are those that, by reason of the rise of moisture in walls, or through ground air, warp or buckle and withdraw from the backing against which they are placed. Some of the newer preparations give promise of good results, but no final estimate of their worth

can be given at this time. It is safe to say that either slate or glass should be used where a community is seeking for the best, and that these materials should measure up to the standard demanded.

My experience with blackboards made of cement mixed with ground slate or other material leads me to fear that most of them will cut the chalk too freely, and consequently will liberate an unnecessary amount of chalk dust in the room.

Location of Blackboards. — In classrooms for the intermediate and higher grades, where unilateral lighting is used, blackboards may be safely placed on three sides of the room. They should never be put between windows, whether these be close together or well separated. When the eyes are turned toward an illuminated surface, they naturally and automatically adjust themselves to permit only as much light as is necessary to clear vision. The reader can make this clear by performing the following simple experiment. Stand before a window through which bright light is streaming, and, by the use of a small hand mirror, note the size of the pupil of the eye, as well as the feeling of eye strain due to the amount of direct light entering the eye. Then face about so that the direct light from the window will not enter the eyes. Note the enlarged pupils and the relief that comes.

When children have to face windows in looking toward a blackboard, their eyes are automatically adjusted to the stronger light, and hence out of adjustment to see easily and clearly what is written on the board. When the boards are placed opposite the windows, the eyes are adjusted only to the light reflected from the board, and if the illumination is sufficient, vision is easy and restful. This, then, is the best location for blackboards, and the wall space opposite windows ought to be saved as much as possible for this purpose. The front and rear of the room may be used advantageously for board space, and, unless the material used reflects high lights, these locations will prove satisfactory.

Height of Blackboard from the Floor. — It is a very common fault to set blackboards for the primary and intermediate grades too high above the floor. Again and again I have seen small children stand on benches in order to reach the board. This is doubly bad; for it not only puts the board out of easy reach, but it darkens the walls of the room for too great a height. An ordinary child of seven years of age is approximately forty-four inches in height, and from the floor to the level of his eyes is about forty inches. He needs to have some free space above the chalk trough for his writing, so that he will not have to do his work at too great a height above the line of vision. If, therefore, the lower part of the board in the classrooms for little folks be placed twenty-six inches above the floor, and be made from thirty to thirty-six inches wide, several advantages will be gained. It is important to have enough board room, but is harmful to have more than is needed, or more than can be used. On the teacher's end of the room, the board ought to be four feet wide, so that she can put such work as she wants the children to observe for some length of time well out of their reach. Furthermore, this height of the blackened surface in front of the children is, on the whole, an advantage rather than otherwise. Naturally it absorbs light, but it serves to prevent the glare that would to some extent come into their eyes from a more extended white or tinted wall. The board in the back of the room, if it is needed at all, should be set as the one opposite the windows. In the elementary grades and high school, the boards can be set from thirty to thirty-eight inches above the floor, and the slabs should be at least three and one half feet wide.

Covering Blackboards to prevent the Absorption of Light. — Much criticism has been directed against blackboards because they absorb much light, and do not at all times present a neat appearance. This criticism is partly justifiable; but in well-lighted rooms there is so little danger from this cause that it is

negligible. However, on dark days and in rooms with insufficient illumination, some relief may be obtained by drawing light-colored window shades over the blackboards. These may be fastened just above the board, and pulled down when more light is needed and when the board is not in actual use.

Dangers of Chalk Dust. — All teachers know by experience how disagreeable it is to breathe chalk dust, and how harsh it makes their throats feel. Fewer teachers know that it often contains great numbers of bacteria gathered from the air of the schoolroom or from the dirt rubbed off of the children's hands as they write their work and erase it. It requires careful training to prevent children from erasing with the fleshy part of the hand, or from wetting the fingers in the mouth and erasing with the finger tips. It is needless to say that such procedure is filthy, and should be prevented. This is best accomplished by having a good supply of clean erasers at hand, thus avoiding the temptation to erase otherwise, and by teaching children the dangers lurking in what may seem to be "clean" chalk dust.

Cleaning Erasers. — Where a vacuum cleaning system is installed in a school building, erasers may be quickly and safely cleaned in the same way as the floor. To make this possible, a shallow box should be constructed and the erasers packed into it backside down. The box should be made to hold only a given number, say twenty, and should be shallow enough to allow the erasing surfaces to extend slightly above the sides. The janitor can gather them up in this box, and after cleaning them, return them in the same way. This will prevent them from being dropped on the floor or handled much. The best tool for this kind of vacuum work has not been devised yet, but the smaller tools for the floors may be used with fair success. By this means the most annoying dust common in a schoolroom is safely and permanently removed. In most schools, however, no appliances for vacuum cleaning are available. In these, erasers must be cleaned by knocking the dust out, at

a safe distance from the schoolrooms. In this respect teachers as well as janitors are frequently careless. Generally, erasers are not kept sufficiently clean, as the blackboards often indicate, and as the clothing of the children at the board will testify.

Dustless Crayon. — It is plainly impossible to make dustless crayons, for were they dustless, they would leave no mark. All advertisements of "dustless crayons" are either false, or else they use the word "dustless" relatively. Some kinds of crayons are not so soft as others, do not cut so easily, and hence do not leave so much dust. A good quality of talc leaves less dust than crayon, but does not make as heavy a mark as crayon. There is absolutely no practicable medium for writing upon a blackboard that does not release dust.

Dustless Erasers. — This term is applied by manufacturers to those erasers that are made so as to gather and hold the dust most easily and persistently. Here, again, "dustless" is only a relative term, for no eraser can continually gather dust without giving out dust. A wet sponge is about the only dustless eraser possible, but is limited to occasional use when the board needs a thorough cleansing. During work at the board a dry eraser is the only practicable one. The use of good erasers is important, and their selection should be left largely to the teachers who have to use them.

Protection against Chalk Dust. — Most of the chalk dust removed from the board either clings to the eraser, or falls into the chalk trough below the board. Pupils may be taught to handle an eraser so as to scatter little dust in the room, though this will necessitate keeping the erasers well cleaned. The chalk trough should be large enough to hold erasers as well as the crayons and the dust. A simple device for keeping the crayons and erasers from coming into contact with the dust in the bottom of the trough may be made in the following way: Cut strips of one-eighth-inch meshed wire just wide enough to fit horizontally into the trough; hinge them

carefully with staples so that they may be lifted easily and will not serve as a hindrance when the trough is being cleaned. It is necessary to select a wire mesh in which the wires are soldered together at the crossings. When this wire is in place in the trough, it readily permits the dust to go through, but holds the brush and the crayons above the dust. The strips should not be over six feet in length, so that they may be handled with little trouble. Such a simple device will aid greatly in preventing the dust from being gathered up by the erasers or crayons and so scattered in the air to gather on the clothing and hands of the pupils. At proper intervals the dust may be removed by scattering a little damp sawdust over it and thus brushing it along the trough to an exit provided for it. This exit is best made by cutting convenient holes in the trough and closing them below with some form of sliding stop. A good-sized cork, a wooden plug, or, better, a sliding button may be used. In this way, the dust may be taken from the trough without scattering it, as is usually done when such openings are not provided.

TOPICS FOR INVESTIGATION

1. Study the sites of as many school buildings as you can in the country and city, and determine what rating you would give each on the basis of rightful demands.

2. How much land should be allotted to a class of forty-five school children so that they may have ample room for play, nature study, and practical agriculture?

3. Select a schoolhouse badly located with reference to noise and one far removed from such disturbances, and determine as far as possible by careful observation the advantage to children who use the latter.

4. Study the statistics relative to the effect on health of locating dwelling houses on damp, undrained land.

5. What is the composition of "ground air"? How does it differ from the air above ground?

6. Is it practicable for many cities to remove their school buildings for the elementary grades and high schools to the outskirts of the cities, away from factories and unhygienic surroundings, and transport those

pupils who live at too great distances to and from school morning and night? What advantages would such a plan introduce? What disadvantages?

7. If city children were required to walk farther to school, would it not give them exercise that many of them need?

8. Determine the best construction and best usage of basements under school buildings. Note all points mentioned in the text and set forth such others as may occur to you.

9. Set forth in detail all the facts that you can find and those that you can discover which will enable you to determine with approximate accuracy the proper dimensions of a classroom for forty pupils of the elementary grades.

10. Study the floors of school buildings, so as to determine what sort to recommend to school authorities. Explain how they may be kept in the best condition.

11. Take an ordinary general high school program, find out how many classes there are daily, how many pupils there have been in each subject listed for the past five years, and, on the basis of this information, plan the size and number of rooms needed for these classes.

12. Locker rooms for high schools are often located in basements. Is this location justifiable, taking all conditions into consideration? Why?

13. Make a careful investigation of a number of school buildings in which transoms are found, in order to determine fairly and accurately the practical value that they have had, and also the troubles that they have caused by catching dust. Note their condition as you find them.

14. Do you think doors without panels are to be preferred to doors with panels?

15. Of what advantage are platforms for teachers? What disadvantages have they?

16. Experiment with glass blackboards in order to determine what color is most satisfactory. (A sliding frame into which various colored paper may be placed behind the glass will furnish an easy method of changing the color.)

17. Make careful note of the amount of blackboard surface needed for various grades, and for mixed grades.

18. Devise a method of cleaning erasers so as to keep them clean with the least effort, and so as to scatter as little of the chalk dust in the room as possible.

19. Try the method of covering up the blackboards on dark days, as suggested, and note the effect.

20. Would it be more in accord with the laws of hygiene to use black crayon on a white board, than white crayon on a blackboard? Why?

21. Experiment with the various kinds of blackboards now on the market in order to determine as far as possible what kind is to be preferred.

22. What height above the floor should the bottom of the blackboard be for each grade, including the high school? Note the demands for each subject.

23. Would American schools lose or gain by adopting the German method of having blackboard space for the teacher only?

24. Experiment with various kinds of crayons and talc to determine which gives the best results on the boards that you are using.

25. Are your blackboards properly located? Why?

26. How can the walls in schoolrooms be decorated to best advantage?

27. Are the restrictions set on the height of school buildings justifiable? Why?

28. Make an investigation into the relative cost of wood, brick, stone, and concrete construction for school buildings.

29. Which seems more likely to meet the hygienic requirements of school buildings, wood, brick, stone, or concrete?

30. How wide should the halls be for an elementary school building? High school?

31. Make a careful study of the needs of assembly rooms, and the best position in the building for them. (See the reference on *American Schoolhouses*.)

SELECTED REFERENCES

BARRY, W. F. *The Hygiene of the Schoolroom.* New York, 1903. 195 pp., illus.

Boston School Committee. *Annual Reports Schoolhouse Committee.*

BRIGGS, W. F. *Modern American School Buildings.* New York, 1909. 411 pp., illus.

BRUCE, W. G. *School Architecture.* Milwaukee, 1910. 285 pp., illus.

BURGERSTEIN and NETOLITZKY. *Schulhygiene.* Jena, 1902. 997 pp., illus.

BURRAGE and BAILEY. *School Sanitation and Decoration.* New York, 1899. 224 pp., illus.

CLAY, FELIX. *Modern School Buildings.* London, 1906. 555 pp., illus.

COPEMAN, S. M. *Influence of Soil on Health.* In a treatise on hygiene and public health (edited by Stephen and Murphy). London. pp. 309–312.

CROWLEY, R. H. *The Hygiene of School Life.* London, 1910. 403 pp.

DRESSLAR, F. B. *American Schoolhouses.* U. S. Bureau of Education Bulletin No. 5, 1910. 133 pp., illus.

ELLIS, A. C., and KUEHNE, H. *School Buildings.* Austin, 1905. 125 pp., illus.

EULENBERG and BACH. *Schulgesundheitslehre.* Berlin, 1900. 1390 pp.

FLETCHER B. F. and H. P. *Architectural Hygiene.* London, 1911. 284 pp.

GERHARD, W. P. *Sanitation of Public Buildings* (Chap. IV). New York, 1907. 262 pp.

HAMLIN, SNYDER, and Others. *Modern Schoolhouses.* New York, 1910. 61 pp., illus.

JOHNSTON BROTHERS. *Plans and Specifications for Small School Buildings.* (For New Mexico), 1909. 94 pp., illus.

MILLS, W. T. *American School Building Standards.* Columbus, 1910. 324 pp., illus.

LYSTER, R. A. *School Hygiene.* London, 1908. 359 pp., illus.

MOORE, J. A. *The Schoolhouse, its Heating and Ventilation.* Boston, 1905. 204 pp.

MORRISON, G. B. *School Architecture and Hygiene.* New York, 1910. 56 pp., illus.

New York State Department of Public Instruction. *Recent School Architecture.* Albany, 1897. 425 pp., illus.

PARSONS AND SON. *School Buildings.* 175 pp., illus.

RICE, MRS. I. L. *"Quiet Zones" for Schools.* Forum, v. 46, pp. 731–742.

ROBSON, P. A. *School Planning.* London, 1911. 108 pp., illus.

SHAW, E. R. *School Hygiene.* New York, 1901. 260 pp., illus.

YOUNG, A. G. *Seventh Annual Report of the Maine State Board of Health,* 1892. 399 pp., illus.

WHEELWRIGHT, E. M. *School Architecture.* Boston, 1901. 324 pp., illus.

American School Board Journal. Milwaukee. Monthly.

Pedagogical Seminary. Worcester. Quarterly.

Das Schulhaus. Berlin. Monthly.

Das Schulzimmer. Charlottenburg. Quarterly.

Zeitschrift für Schulgesundheitspflege. Hamburg. Monthly.

BLACKBOARDS

DRESSLAR, F. B. *Blackboards.* Cyclopedia of Education. New York, 1911.

FARLEY, D. H. *The Proper Use of Blackboards.* Educational Foundations, v. 21, pp. 534–541.

PERRY, A. C. "The Use of the Blackboard." In his *Problems of the Elementary School.* New York, 1910.

(See the various texts on general school hygiene for additional references.)

CHAPTER IV

LIGHTING OF SCHOOLHOUSES

Amount of Glass Surface Needed. — In every schoolroom of the normal size with proper orientation and unhindered sky exposure, there should be from one fourth to one sixth as much glass surface as floor surface. That is to say, in a schoolroom thirty-two feet long and twenty-four feet wide, provision should be made for from one hundred and twenty-eight to one hundred and ninety-two square feet of glazing. In the south and southwestern parts of our country, however, there is less difference in the duration of daylight for summer and winter, the sun's path is higher above the horizon, and there are fewer foggy days during the year. In these parts, and especially in the southwest, where the glare of the sun reflected from brown fields or mountains is sometimes very trying, one hundred and twenty-eight to one hundred and fifty square feet of glass surface for a room of this size is sufficient. This amount will suffice, however, only on condition that the windows are properly placed, where they face either to the east or west, and where in every case they have unhindered exposure to the sky. Under the topic on Orientation there have been given the reasons for the preference for east and west exposure over that toward other points of the compass.

In the north, where the days during the winter are relatively short and there are many dull days during the school year, it is often necessary to have a greater window area. In smoky cities where tall buildings, often in the immediate neighborhood of schools, and in all positions where near-by mountain ranges or high hills raise the sky line on the window

sides, it has been found advisable and even necessary to have one fourth as many square feet of glass in the windows, as there are square feet in the floor surface.

In climates where the winters are long and cold, double windows are necessary, and these of necessity reduce the light somewhat, hence allowance must be made to offset this loss.

Regulations in Foreign Countries. — Baginsky gives in a table the amount of glass surface relative to floor surface in all the newer buildings of Berlin, and this runs from about twenty-three per cent to sixteen per cent; but the great majority of them have about twenty per cent as much glass surface as floor surface.[1]

Sir Ashton Webb in a paper read before the Second International Congress on School Hygiene held in London, 1907, says: —

"The Board of Education lay down one fifth as the approximate area of window glass to the floor area, to light a classroom satisfactorily. In very confined sites, however, one quarter is sometimes found necessary, and in open and exposed sites, one sixth will sometimes suffice. Anything beyond the amount of glass actually necessary to give a satisfactory light is undesirable, as it tends to make the room cold in winter and hot in summer, and adds considerably to the difficulty of the effective treatment of the room both externally and internally. The glass line should not be more than four feet above the floor, with the heads of the windows carried up as near the ceiling as possible."[2]

Nearly all the progressive European countries have, in recent years, enacted laws fixing the amount of window surface for all new school buildings from one fourth to one sixth of the floor surface. It must not be forgotten, however, that these proportions will prove satisfactory only when windows are properly placed in the room, when they have the best orienta-

[1] See Baginsky, *Schulhygiene*, Vol. I, p. 260. Stuttgart, 1898.

[2] See Transactions, Vol. I, p. 58.

tion and are not rendered more or less ineffective by outside obstructions. It is of the utmost importance to place the windows in the schoolroom in the right position, and I wish to emphasize this point, for here is perhaps the most difficult problem for the architect to solve.

Difficulty of placing Windows to secure Enough Surface.—If the schoolroom is thirty-two feet long, twenty-four feet wide, and twelve and one half feet clear from floor to ceiling, we must, if we have one fourth as much glazing as floor surface, handle the wall space carefully.

Height of the Lower Part of the Windows above the Floor.—To begin with, the bottom of the windows in the rooms designed for the primary classes should be at least three feet six inches from the floor, and for all upper grades, including high schools, they should be set four feet above the floor. There are several reasons for these demands. The bottom of all schoolroom windows should be higher than the eyes of the pupils when seated at their desks, in order that no light from the windows may shine directly into their eyes while they study. The light needed is that reflected into the eye from the page of the book or the written work upon which the pupil is engaged. If the strong direct light from the windows strikes the retinæ, automatic adjustment of the eyes takes place to suit this, and hence of necessity, maladjustment for the weaker light reflected from the page must follow. If, therefore, the eyes are subjected to the stimulations of two or more sources of light of unequal intensity, there will be a conflict between the demands of these stimuli, varying with the conscious attempts of the person to adjust to one or the other. Every one knows, or can readily see by shading his own eyes and watching their action in a mirror, that the pupils automatically contract when the light is strong and expand when the light is reduced. If windows in a schoolroom are set so low that the direct light from them enters the eyes of the pupil while he is at work, there will be a constant attempt, more or less unconscious, to shade

his eyes from the windows, or else he will be subjected to the strain of unhygienic vision and fatigue of the ciliary muscles. It has been my habit in attempting to bring this point forcibly to the attention of architects and school officers, to have them take a position near a window lower than their eyes and, after having them read for a few moments, place a board across the lower part of the window so as virtually to raise the line of light well above their eyes, and ask them for their preference. By repeating this experiment several times so that they will directly sense the relief that the higher window gives, you are then in a position to put your question forcibly, viz.: "Do you think it would be wise, or even humane, to build a schoolhouse, that will probably last for a hundred years, with windows so placed that hour after hour, and day after day, the little children or young people who attend our schools, and who are more sensitive than we, would be compelled to suffer this inconvenience and fatiguing strain?" The answer that you will get is the one that you want; but you have gained other points besides. You have taught them that you know something about schoolhouse construction that they had never thought of, and you have opened the way for coöperation, which will eventually produce willingness to follow the advice of one who knows the demands of the schoolroom.

Recently, in a discussion of this matter a practical schoolman objected to the windows being set so high, saying that, in case of fire it would be difficult for the children to climb out. While this objection might have some weight for the primary grades, it could not apply to the upper grades. However, since it is a rational and an almost universal plan to house the primary pupils on the ground floors of our schools, in buildings that are safely constructed with reference to fire protection, it is less dangerous for the pupils to be sent out directly through the doors than through the windows. I therefore see no real basis for this objection.

Again, it is claimed that it is not wise to shut out the world from the children by making the bottoms of the windows so high from the floor that they cannot see out without standing. No one is more anxious than I am to let the children see, but I do not think much good can come from mixing work and play. If at any time it is well for the children to look out, send them to the windows or, better still, send them out of doors to look about. But there is one thing that they always need, one habit of great importance that they should acquire, and that is to hold fast to the work in hand until it is done. "Work while you work, and play while you play" is an old saw embodying a bit of sound mental economy.

Then there is still another reason why windows should be placed from three and one half to four feet above the floor. This arrangement enables you to get your architect to extend the windows nearer to the ceiling. In fact, it becomes necessary for him to do so, or else he will not be able to supply the requisite amount of window space in one side of the room. One foot of glass surface near the ceiling of a schoolroom is worth more than two feet at the bottom of a low window, especially in rooms on the ground floor, for the reason that from thence the light is thoroughly diffused over the room, and especially because a great deal more light enters the upper part of a window than the lower part. This statement holds good, of course, only when no unnatural obstruction prevents. The upper part of a window properly exposed to the light has a lower horizon line, gathers up more reflected light, carries it farther across the room, and lets it fall more directly downward on the work in which the pupils are engaged.

Height of Windows. — These reasons then enable us to give another practical and important direction to architects and builders: windows in schoolrooms ought to extend as near to the ceiling as the exigencies of construction will permit; and since it is not now prohibitively expensive to employ iron and steel beams where needed, windows can extend to within

six inches of the ceiling without any necessary danger to the strength of the building. The top of the glass surface of the window should be at least twelve feet above the floor, thus allowing eight feet at least as the length of each window. Such a position of the windows, contrary to the *a priori* criticism of those who have never looked, gives them a more artistic appearance from within the schoolroom than the old-style setting, which gives a "spotty effect."

Unilateral Lighting of Schoolrooms. — The windows designed for lighting schoolrooms should be placed on one side, and on one side only. The reasons for this direction are not obvious to those who have given no serious attention to school architecture. When windows open from opposite sides of the room, there can be but one line through the room along which the light will be equally strong from both sides, and this line is shifting because of the changes in relative strength of the light due to the changing position of the sun, and other less important factors. In all other parts of the schoolroom, the pupils will have to work under the annoyances of unequal cross lights, and with the added difficulty that they can practically face no part of the room without exposing their eyes to the direct rays of light from a window. If one happens to sit near the windows placed on his right side, and he writes with his right hand, he of course must constantly suffer the annoyance and ill effects of having to work in the shadow of his hand. Furthermore, where windows are found on two sides of a schoolroom, they are usually placed so far apart as to introduce wedges of shadow from the walls between the windows, and these are often troublesome to those sitting near an outer wall. Then, too, with windows on both sides, the most of the available blackboard space will have been used up, and the spaces left between the windows will probably be utilized for blackboards. This will be most disastrous, for the eyes looking from a distance toward a blackboard so placed cannot see the work without painful and fatiguing adjustments.

General Ignorance concerning the Laws of Vision. — It is almost appalling to know how much ignorance is still abroad in our land touching the simplest laws of vision. I had a physician, an average country doctor, complain to me about unilateral lighting for schools, on the basis, as he claimed, that unilateral lighting compelled the children to use but one eye! He thought, as a great many otherwise intelligent people think, that in order for the child to see an object, the light from a window must fall directly into his eye and, as it were, reflect from his eye to his book. Such people, and the teaching profession is not free from them, do not adequately realize that the only light needed, and used for vision, is that which is *reflected from the object* to which our eyes are directed.

Placing the Windows. — When unilateral lighting is used, and this in my opinion is the only kind of lighting that should be used, the windows ought to be placed as far to the rear of the room as possible, and the mullions between the windows made as narrow as safety of construction will permit. Thick, heavy mullions not only obstruct a great amount of light that would otherwise enter the schoolroom, but they use up the space in the wall so that in order to get a sufficient amount of window space, the windows must be carried too far to the front. If we consider a wall thirty-two feet long and thirteen and one half feet high (one foot higher than a standard room), where the windows are not to extend below the four-foot line from the floor, we must economize space in order not to carry the windows so far to the front of the room. If this is not done, many children who happen to sit toward the rear corner on the side away from the windows will be exposed to a glaring light every time they lift their eyes from their work, or attend to the directions of the teacher from the front of the room.

Suppose, therefore, we enter into a calculation with a view of locating the required amount of glass surface as far to the rear as the conditions that we have set for ourselves will per-

mit. The floor space of the room that we have under consideration, and that which, all things considered, is most satisfactory, for grammar schools and larger high school classes, amounts to seven hundred and sixty-eight square feet. If, therefore, conditions demand one fourth as much glass surface as floor surface, our windows must, inside the frames and sash, show a surface of one hundred and ninety-two square feet. By placing the glass four feet from the floor, and extending it to within six inches of the ceiling, we have nine feet as the length of the windows. Dividing one hundred and ninety-two by nine, we find that there must be twenty-one and one third feet of the thirty-two feet of wall space used for windows. Allowing the rear window to approach within eighteen inches of the rear wall of the room, allowing twelve inches for the thickness of a mullion, frame, and sash, and making each window three and one half feet wide, we find that six windows, each with glass three and one half feet wide, will extend to within four and one half feet of the front end of the room, thus practically using up the whole of the available wall surface.

It will be noticed that, in this calculation, we have taken a room thirteen and one half feet high; while this is higher than it ought to be, it is necessary for unilateral lighting, where light conditions demand a ratio of one to four between window and floor surface. Under no other ordinary conditions can the requisite glass surface be properly placed. Even this brings the windows nearer the front end of the room than is desirable.

If the rooms under consideration are on the first floor and are designed for the primary grades, the windows may be lowered six inches, and the ceiling lowered an equal distance, giving the same placing as the windows in the room above, designed for the upper grades or high schools.

I have purposely chosen to make the first calculation on the basis of one to four; but, as I have remarked elsewhere, it is only in badly located school grounds, and especially in the

northern cities, that this ratio ought to prevail. In the south and southwest if there are no mountains or other obstructions in the way, a ratio of one to six will prove entirely satisfactory, if other conditions justify. Let us therefore make a calculation based on this ratio. If, as before, we have seven hundred and sixty-eight square feet of floor surface, we must set one hundred and twenty-eight square feet of glass. This time, making the room twelve and one half feet high, placing the lower glass four feet from the floor, we have a window eight

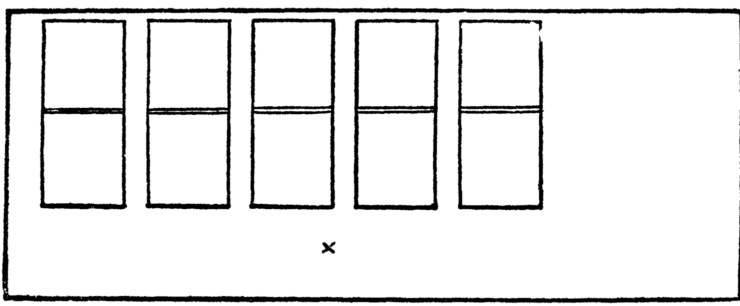


Fig. 6. — Proper location of windows for conditions named: lower part of the windows, four feet above the floor; distance from floor to ceiling, twelve and one half feet; top of windows, twelve feet above the floor; windows, three and one half feet wide; mullions (supports between windows), one foot wide; distance of rear window from rear wall, eighteen inches; distance from front end of room to first window, nine feet. The cross marks the center of the schoolroom population.

feet high. Dividing one hundred and twenty-eight by eight, we find that we must use sixteen feet of the wall for actual glass surface. Again, setting the rear window within one and one half feet of the rear wall, making mullions, frames, and sash twelve inches thick from glass to glass, and five windows three and one half feet wide, glass measurement, we find that we have more than met the one to six requirement and still have nine feet of dead wall space in front. The accompanying figure will make this clear at a glance.

Dead Wall Space in Front of Windows. — Some objections may be urged against a solid or blind wall of nine feet in front

of the windows, and no serious complaint could be made against reducing this space a foot or so by making the windows narrower and adding one more, or even by lowering the top of the windows a couple of inches; but schoolhouse architects and builders, as well as school boards, should be led to see, and see clearly, that the only light that is effective in a schoolroom is that which is reflected from the work upon which the pupils may be engaged. Hence light from the left is the light that is needed. The front row of pupils, when they are properly seated in a schoolroom, rarely, if ever, is nearer the teacher's end of the room than eight feet. In fact, the front row of seats is often placed at least ten feet from the front of the room. Thus with a blank wall of even ten feet in front of windows, no pupil in the front of the room is badly situated with reference to the light; and those in the rear of the room, especially those nearest the inner wall, will be greatly relieved from the glare of windows every time their eyes are directed toward the front of the room. This position of the windows concentrates the light and delivers it upon the desks of the pupils, and directly opposite the center of population in the room.

Width of Mullions. — Doubtless one of the first objections that builders will urge against this arrangement of windows will be that the mullions are too narrow for adequate support, especially if the building is to be two stories high, and this figure represents a room on the ground floor. The objection is worthy of serious consideration, and if simply brick or stone construction is considered, mullions of this width would not give safe and adequate support. But years ago Mr. Briggs devised a metal mullion which solves this problem and at the same time makes it possible to take greater advantage of the amount of window space indicated.

He says: —

"It is hardly possible, even in the smaller brick buildings, to construct with safety the brick piers or mullions between windows less than twelve

inches in width; in larger structures they need to be sixteen, twenty, twenty-four, twenty-eight inches, and sometimes piers of from three to four feet are required to obtain sufficient strength. To obviate the heavy shadows that these piers must cast, and to obtain the maximum strength with the minimum construction, I have recently introduced into my buildings, with marked success, iron mullions cast with heavy flanges or webs. The window frames are bolted directly to these mullions, the outer portions of which are made wedge-shaped, running nearly to a sharp edge. It will be readily seen that by this simple device very little more space is occupied by the supporting mullion or pier than that actually required by the frames and weight boxes; in fact, the saving is so great that six windows can be introduced in the same space which would be occupied by five, having the ordinary sixteen-inch brick pier between them, *the expenses in both cases being practically the same.*"

He adds: —

"The strength of the mullions can be regulated by the thickness of the shell and web, so that, with little or no change of outside dimensions, they can be used to support almost any weight. In small frame buildings a similar mullion can be made of hard wood that will be strong enough for ordinary purposes."[1]

Since this form of mullion has been adapted to many conditions by Mr. Briggs, and he has declared each adaptation successful, there seems to be no excuse for architects to resist further the efforts of schoolmen to group the windows closely together. Furthermore, in buildings where walls are not of necessity thick and heavy, the same result may be obtained by supporting part of the weight from above by using a steel beam as a lintel, and thus with the aid of narrow mullions, getting adequate and safe support. Others have used the arch form of lintel in order to transform the main strain of the weight above the windows into a side thrust, and have thus transferred the strain more or less to the main walls in front of and behind the windows. This, it seems to me, is not advisable, especially on account of the necessity of having to encroach upon the window surface on both sides due to the curve of the

[1] See *Modern American School Buildings*, Warren Richard Briggs, pp. 122 f.

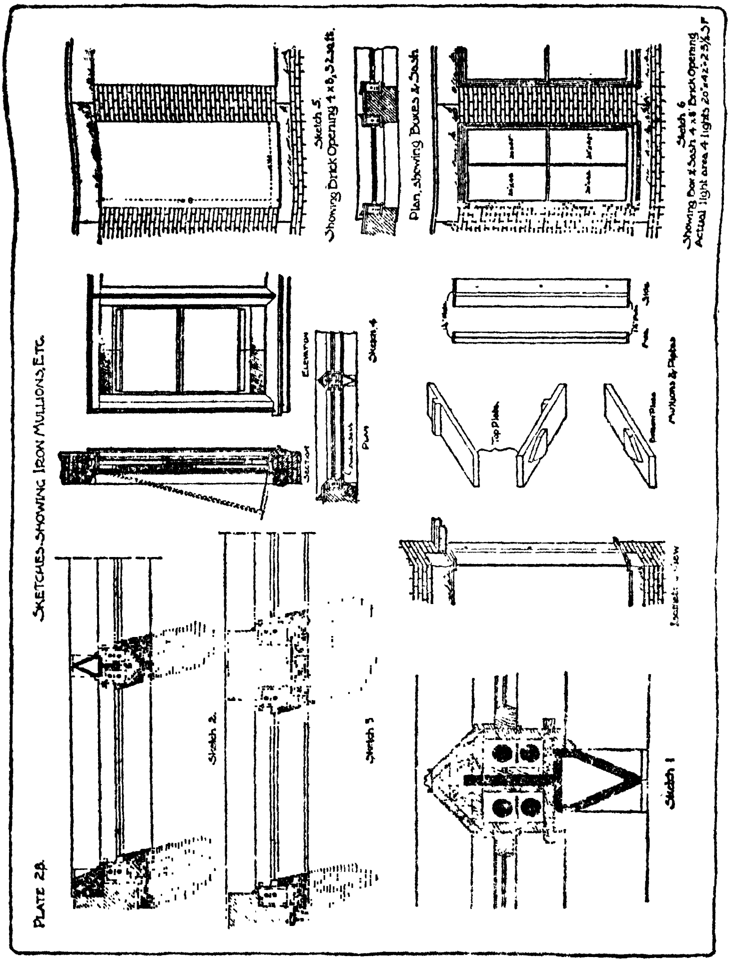


FIG. 7. — From *Modern American Schoolbuildings*, by Warren R. Briggs. By permission of the author.

arched form. Mr. Snyder, the distinguished architect who has had charge for many years of the school buildings of New York City, has used the steel lintel in many of his largest and most successful buildings. By reference to Fig. 8, p. 66, it may be seen very readily that in this building he has relied almost wholly on the strength of a long steel lintel to support the weight of the walls directly above the windows. This, of course, is a very much easier thing to do with a steel-framed building than where the main strength must lie in brick or stone piers. But a combination of metal mullions, such as described by Mr. Briggs, and the metal lintel just referred to is entirely feasible, and any architect with a modicum of originality can easily design sufficient and safe supports so that windows may be grouped together as we have indicated.

Naturally the form and finish of the framing material used about the windows will be adjusted to the general form of finish used in the building as a whole.

Added strength might be obtained if there seemed need for it by filling the cavity of the Briggs mullions, after they have been put in place and before the upper cap has been put on, with a good quality of cement mortar. This, however, appears to be unnecessary; at least it has not been mentioned by Mr. Briggs.

Especial attention ought to be directed to the wedge shape of the iron mullion designed by Mr. Briggs. This edge is for the outside, and by reason of its beveled form it permits a wider gathering in of light and eliminates much of the shadow otherwise cast by the mullion.

The Danger of Facing Windows. — There is no excuse at all in this day and age for any one to construct a school building with windows facing the children, though this was not uncommon a few years ago. If any teacher is called on to teach in one of these old buildings, of course the thing to do is to cover the window permanently with opaque curtains so fastened to the sash that no beams of light can find their way into the room.

"**Breeze Windows.**" — Neither should there be any windows built in the rear of a room for purposes of light. But in the south and in the hot valleys of the west, where during the warm days of spring and fall it is most acceptable to have a breeze sweep through the room, two or more windows should be built into the rear wall, where it can be done, for the sake of such a breeze. The bottoms of these windows should be at least eight feet from the floor, and the tops of them should be on a level with the windows set for light. The size and proportion of these windows ought to be made to harmonize with the room. The best way to set these windows is to hinge them on the lower side and fasten them above with a spring catch. The only difficulty that this arrangement introduces, is the one of making the windows fit the frames in such a way as to prevent beating rains from driving in. This may be done by the method used in old French casement windows. The advantages of hinging these windows on the lower side are several. Hinging permits the placing of a permanent opaque shade over the glass, for at no time do we want light from these windows to enter the schoolroom, unless it is reflected to the ceiling. In the next place, when the window is opened from above, it can be adjusted to regulate the amount of draft that may come in. Then, too, by proper cords the window may be easily opened or closed from the floor. It is advisable to shut out all the light from entering the room through these windows, else the teacher would be seriously troubled with light shining directly in her face. The number and size of these windows may be regulated to suit the outside appearance, as well as the demands of the climate. In buildings showing wooden or beamed construction on the interior, stained glass of good quality and harmonious coloring set in these small rear windows would add to the artistic atmosphere of the room; but stained glass should never be used unless of high grade and harmoniously blended. There is nothing more tiresome and displeasing than make-believe art.

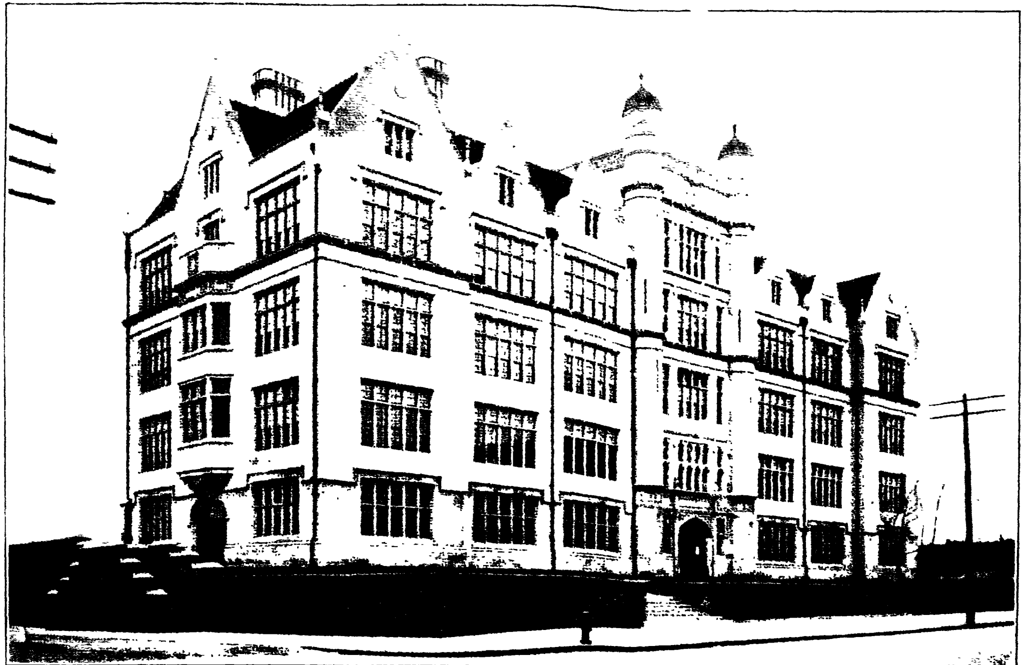


FIG. 8.—Public School, New York City. C. B. J. Snyder, architect. Note the placing and construction of the windows. (From *American Schoolhouses*. Courtesy U. S. Bureau of Education.)

In general, if any attempt be made at decoration in these windows, a pleasing design of leaded glass will be found most successful. We must not forget, however, that the main purpose of introducing these windows is for the sake of ventilation in hot weather, and hence they must all be designed to open and close easily, and be so set as to prevent rains from driving in about them.

Orientation. — In the latitude of our country, it is essential, if we hope to light the schoolrooms properly, to open as many as possible of the windows toward the east or west. The east light is usually best, the south is most trying and troublesome, the west is good, and the north to be used only for those rooms designed for art work in its various forms.

East Light. — Windows opening toward the east permit the early sun to warm and purify the room before school hours, and by ten o'clock or an hour after school work has begun, the direct rays of the sun have almost disappeared from the room; especially is this true during a large part of the school year, when the sun's path is south of the equator. Therefore, during the rest of the day the window shades may be rolled up, and the clear white light of the eastern sky may be allowed to flood the room without producing a glare. The only disadvantage I can think of in rooms so lighted is this: it will necessitate the pupils facing the south in order to get the light from the left side, and this orientation puts them to a disadvantage in map work. To many this may not seem of very great importance, and it is not at all a fatal objection; still, as far as possible, it is wise to use a room where the pupils can face the north when maps are being used.[1] But, this objection aside, in selecting a lot, planning a building, and

[1] Personally I have had a sort of mental twist for geography ever since childhood, because I first used an atlas while I sat facing the south. The distinct feeling of unreality and mix up which I had to combat when the top of my map pointed to the south, and yet I must call it north, I shall never forget. Even to-day I must perform a sort of mental "bucking" process every time I take a map, in order to make things seem real.

locating it on the lot, the matter of good lighting must play a very important part.

South Light for Classrooms Bad. — I have already said that the south light is the most trying and troublesome that we can introduce into our classrooms, and this, to many, may seem directly opposed to the demand for plenty of light, since the south light is the strongest during most of the school day. The difficulty with the southern exposure is that it is almost impossible to keep out the direct sunshine and at the same time get sufficient indirect and diffused light into the schoolrooms. If the windows in a classroom open toward the south, despite all that can be done with ordinary shades or blinds, bright rays of the sun will find their way into the room and will inevitably dazzle and disturb the eyes of the children, as well as those of the teacher. A streak of sunshine across a page or a desk at which one is at work is really a serious disturbance, physically, mentally, and sometimes morally, for tired eyes often induce fussy moods. Such rays of light cause a strain on the muscles of accommodation, and distract the attention. It will generally prove a mistake to say that the teacher can regulate the shades so as to prevent all such troubles. Even if the schoolroom were equipped with shades that would make it possible to filter through sufficient diffused light and yet keep back the glare of the direct sunlight, it is unsafe to rely upon teachers to regulate them properly. Teachers are very busy people, with their chief thought centered on lessons and behavior, and it is unfair to expect them to keep a constant watch during the whole school day upon the shifting rays of the sun, so that the room may be furnished with the best and most equitably distributed light. It is far more economical and almost invariably safer to prevent these difficulties by making them impossible.

South windows are troublesome, especially in the southern states, in hot weather; for on sunny days, in order to keep out the heat, teachers very often err by making the rooms too dark.

Children may not object and the teacher may feel that she has chosen the lesser evil; still, tired eyes and frequent head aches will result.

Window Shades Troublesome in Ventilation. — I desire at this point to call attention to another practical difficulty that often enters here. In those buildings depending upon windows for ventilation, it is frequently very difficult, with shades drawn, to effect satisfactory ventilation, especially where we have windows on but one side of the room. What can you do to cut out the direct sunshine and at the same time to permit the air to enter unhindered? Venetian blinds and sliding shutters have been recommended, and these have been introduced into many school buildings. They will often prove very satisfactory in homes, but they do not prove permanently satisfactory for schools. Venetian blinds are noisy when the breeze enters, they cut out the best light when they are gathered together at the top of the window, they often permit pencils of light through chinks, and are rarely adjusted to meet

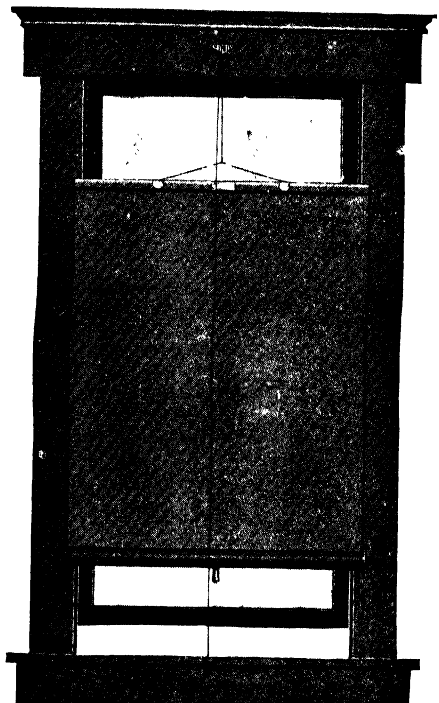


FIG. 9. —The Draper window shade. This simple shade may be easily adjusted to any part of the window.

exact demands and conditions. They are almost invariably fastened to the top of the window, so that in order to shut out sunshine at the bottom of the window they must be pulled down over the whole window surface. They get out of order easily, and any furniture or apparatus that gets out of order quickly balks a woman teacher, for it is a rare woman who knows how to fix such things, or even has sufficient faith to try. But if the so-called folding Venetian blinds will not suffice to regulate properly the light in windows opening toward the south, it will be much more difficult to keep sliding shutters at the right place. They either stick, or get loose and slide down by reason of their own weight; they impede ventilation more than any other form of blind used, and are altogether beyond the teacher's control. These objections are not theoretical ones, but practical difficulties. Years of experience in teaching and in supervising teachers where such conditions existed enable me to state these objections unreservedly. I have never seen a single classroom in our country properly lighted throughout a sunny day, when it depended on light from south windows. Professor Foster of Breslau once said: —

> "No curtains have yet been invented which will keep back the direct rays of the sun and at the same time let the diffused light of the clear sky pass through. Ground glass has been recommended, but this is too dazzling and blinding in the direct rays of the sun, and during cloudy days it intercepts too much light."

Rowe says: —

> "Much better results may be obtained by use of the Venetian blinds than with any other screen for the sun"; but he thinks "their expensiveness, together with a tendency to collect dust and get out of order, will preclude the general use they might otherwise have. I know of no successful inside blinds adapted to school uses."[1]

This digression on shades and blinds is necessary in order to present clearly the difficulties incident to a dependence on

[1] See *The Lighting of Schoolrooms*, Stuart H. Rowe. Longmans, 1904. p. 51.

south light for schoolrooms. Returning, then, to windows with a south exposure, there is still another difficulty, though this may be easily overcome. In school buildings warmed from a central heating plant either by steam or hot air, when rooms lighted by south windows are warm and comfortable, the same steam pressure and radiating surface will not suffice to keep the rooms on the north or the west at the same temperature. Unless, therefore, automatic regulators are installed, the teacher in the south room will be complaining of the heat, while the one in a corresponding room to the north or west will be grumbling because of the cold.

West Light. — Schoolrooms receiving light from the west are often more satisfactory in hot climates for the primary grades than those receiving light from the east, because of the fact that the day's session for these classes ends before the sun is sufficiently low in the horizon to cause any serious disturbance from direct sunlight streaming into the room. This practically eliminates the problem of shades in these rooms; for after school hours it is altogether advisable to allow the sun to beat in and purify the room. Sunlight is the most effective disinfectant known to science. Then, too, this will enable those who begin geography to adjust the points of the compass to the demands of maps, for the pupils in rooms with west light will sit facing the north. But rooms with a west exposure are not on the whole so satisfactory for the upper grades as those on the east. Especially is this true in the hotter parts of our country; for during warm afternoons these rooms are quite uncomfortable from two o'clock until school is dismissed.

North Light. — The light entering windows from the north is well diffused, but for a given amount of glass surface is much weaker than that from the other cardinal points of the compass. When, therefore, a school building is planned, as few rooms should receive north light as possible. For high schools, rooms designed especially for art work may well

receive the north light. Manual training rooms, and chemical laboratories also, may, with no serious disadvantage other than lack of warmth and the purifying influence of sunlight, be constructed to receive the north light. But it is a safe rule, in planning school buildings, to get as many classrooms facing the east or west as possible; utilize the space on the south for libraries, offices, physical laboratories, and biological laboratories, and that on the north for drawing, manual training, and domestic science laboratories.

The reader who has gone through these details of lighting will now understand that the way to avoid many difficulties is to forestall them before a schoolhouse is planned, or at least before the lot is selected or purchased. Many times I have been called into consultation with school boards to help with plans for buildings, where it was impossible to be of any service, notwithstanding the fact that the proposed plans were almost totally wrong. Elaborate plans, it may be, had been made to construct a building to occupy a lot barely wide enough to receive it, and where the light for the majority of the rooms must of necessity come from the north and south. Take, for example, this situation within the author's experience. A lot ninety feet wide by one hundred and sixty feet deep is situated in the middle of a block. It is of great practical importance whether this lot opens toward the east or west or whether it opens to the north or south. As there is but one street frontage, the main entrance must be placed there. Now suppose this opening is toward the east, then, of necessity, some of the best classroom space in the building must be sacrificed, and generally the architect will either be led to depend on north and south light for a majority of the rooms, or else he will crowd the frontage to its very limits. If the latter plan is chosen, he may get, in a two-story building, four rooms with east light and four rooms with west light; but all other rooms must have north or south light, and will receive this from the narrow side of the room, or else the middle rooms will be too big

for ordinary use. Without going into further detailed discussion, it will be readily seen by those who have undertaken to make plans for a modern school building that if this lot opened to the north or south, it would be a great deal easier to get proper lighting, to narrow the building to suit the lot, to economize in construction, and in almost every way to get better plans. Such problems as these ought never to arise, for it is almost criminal to forget the needs of child life so far as even to think of locating a large school building of sixteen classrooms on a lot where absolutely no room can be spared for play, where the outlook from classroom windows would perchance be on chicken coops, tangled clotheslines, and backyard landscapes in general. Far better locate the school building a mile out, if need be, where there will be plenty of room.

Light from Other Directions.—Up to this point nothing has been said with reference to the advisability of facing a school building at an angle of forty-five degrees with a line running north and south. If the windows face toward the northeast and southwest, practically every room in the building would receive a sunning each clear day, and no room would be necessarily deprived of a due amount of light. But there are many disadvantages in such an orientation, and it will be well to consider them briefly.

First and foremost, it would usually place a building in an awkward position on the lot; for, except in special locations, land is surveyed, plotted, and sold with reference to the cardinal points of the compass. For the same reason a school building so placed would not, other things being equal, present a satisfactory appearance from the street or roadway. True, this last objection could be practically overcome by intelligent landscape gardening; but every one knows that it is likely to be a long time before opportunities for much of this delightful work will be offered to school boards.

But suppose the rooms were made to face southeast and

northwest, what then? Those rooms facing toward the southeast would be greatly troubled by the long-continued exposure to the direct rays of the sun. It would be necessary to intercept this direct sunlight during most of the school day, and we have already seen how difficult this is, if we allow for the entrance of sufficient light to satisfy the hygienic demands of vision. Where the main axis of the building is from southeast to northwest, those rooms whose windows would face to the southwest would receive the direct rays of the sun during practically the whole of the afternoon session. Here the same difficulty with reference to direct sunlight would be met as before, and the added disturbance due to the greater intensity of the afternoon temperature. Furthermore orientation along either of these axes would be likely to introduce a greater inequality of light in the various rooms than would come from building along a north and south line. Aside from conditions due to irregular-shaped lots, crooked streets, local obstructions, etc., the general rule for orientation in our country is to build a schoolhouse with its main axis running from north to south, in order that the classrooms, as far as possible, may be supplied with light from the east or west.

Ribbed or Prism Glass. — The problem of lighting rooms too wide for the height of windows, or those situated where sufficient window surface cannot be obtained, or those too close to tall buildings or neighboring trees, has been greatly simplified in recent years by the use of ribbed or prismatic glass. It has been used most extensively in business houses, such as stores, where deep rooms must get all their light from restricted frontage. This glass is not very expensive, and when set high up in a window, increases and diffuses the light in a very helpful way. It is not generally advisable to set such glass in the lower part of the windows of schoolrooms, on account of the glare produced. But for basements, dark hallways, toilet rooms, and closets such glass is especially valuable. For

regular classrooms, as I have suggested, it is most satisfactory when placed in the upper half of the windows. There are now many dark and gloomy schoolrooms in daily use which could be easily transformed into well-lighted, cheerful rooms, if those who manage such schools knew of the benefit of ribbed glass, and were shown that it would be comparatively inexpensive to substitute it for the ordinary glass. Let those who doubt and those who are anxious to serve the children visit some store in the nearest city that makes use of this glass and see for themselves.

Artificial Lighting. — Because of the situation of our country with reference to latitude, comparatively few of our public schools have heretofore needed artificial lighting during the day session. This, therefore, has not been a serious problem with us. But as evening schools multiply, and as school buildings come to be used more and more after school hours for social and educational undertakings, it is rapidly becoming necessary to give this phase of school equipment more consideration. It is highly advisable, therefore, that all plans for high schools, manual training schools, and all other school buildings likely to need either power or light should make provision for electric wiring and for such fixtures as are necessary for immediate use. It is not only difficult to wire a building safely and acceptably after it has been built, but it is also more expensive. For the same reasons gas pipes ought to be installed, for progress is rapid nowadays, and good schoolhouses ought to last a hundred years or more

Electric Light and Gas Light Contrasted. — Electric lighting is much to be preferred to gas, even though the new methods of handling gas flames insure good light. Electric lights give out but little heat, and release no bad odor or noxious gases. They reduce the danger from fires, are far more easily and quickly lighted, require less attention, and offer no dangers from leakage or contamination of any sort. This cannot be said of gas lights under the most favorable conditions yet

devised. Clay gives the following table,[1] prepared by Professor Lewes, which shows the comparative hygienic effect of illumination per unit of light.

	Carbonic Acid Evolved	Moisture Evolved	Oxygen removed from Air	Heat Produced
Acetylene	100	100	100	100
Coal gas, flat flame	480	1470	520	796
Coal gas, mantle	45	230	62	87
Petroleum, large lamp . . .	995	700	498	246

But electric lights are hard on the eyes, particularly when the filaments are visible. It is necessary, therefore, to shield the eyes from these by ground-glass bulbs, or by some form of refractive and dispersing globes surrounding the bulbs. The chief objection to the ground-glass bulb arises from the fact that it permits only about 50 per cent of the light to pass through.

As the result of some extended experiments by Mr. B. B. Hatch, Electrical Engineer for the Schoolhouse Commission of Boston, it was found that for direct lighting —

"the most satisfactory results were obtained from nine thirty-six candle-power, forty-watt Tungsten lamps, each equipped with the diffusing prismatic reflector shown in the accompanying cut. These shades are constructed of prismatic glass coated on the outer or inner surface with a white enamel." He arranged these lights in three rows running parallel to the rows of the desks, and had three lights in each row. He found also that by locating these lamps ten feet six inches above the floor, and in such positions as to throw the center of light distribution "slightly to the left of the middle of the room when facing the teacher's desk," he got an illumination of "2.5 candle feet at every desk." He adds that "the diffusing quality of these shades is so great that the candle-foot illumination on the desk directly below one of the lamps was appreciably no greater than the illumination on the desk on any one corner."

[1] See *Modern School Buildings*, Felix Clay. London, 1902. p. 118.

Through the courtesy of the School Committee, I have permission to reproduce the illustration of this lamp shade and fixture, and also a plan of the schoolroom, showing the exact location of these lamps.

Various forms of holophanes have been used, and the best of these give good light dispersion and at the same time shield the eyes from the glare of the globes. The chief thing, however, for consideration in preparing plans for wiring schoolrooms, assembly halls, and other rooms used for like purposes is to see that the wires are properly placed and that switches are conveniently arranged both for power and lights.

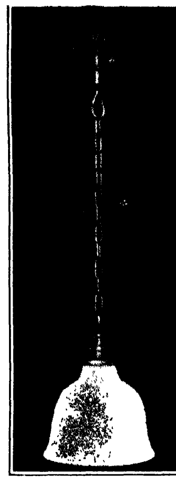
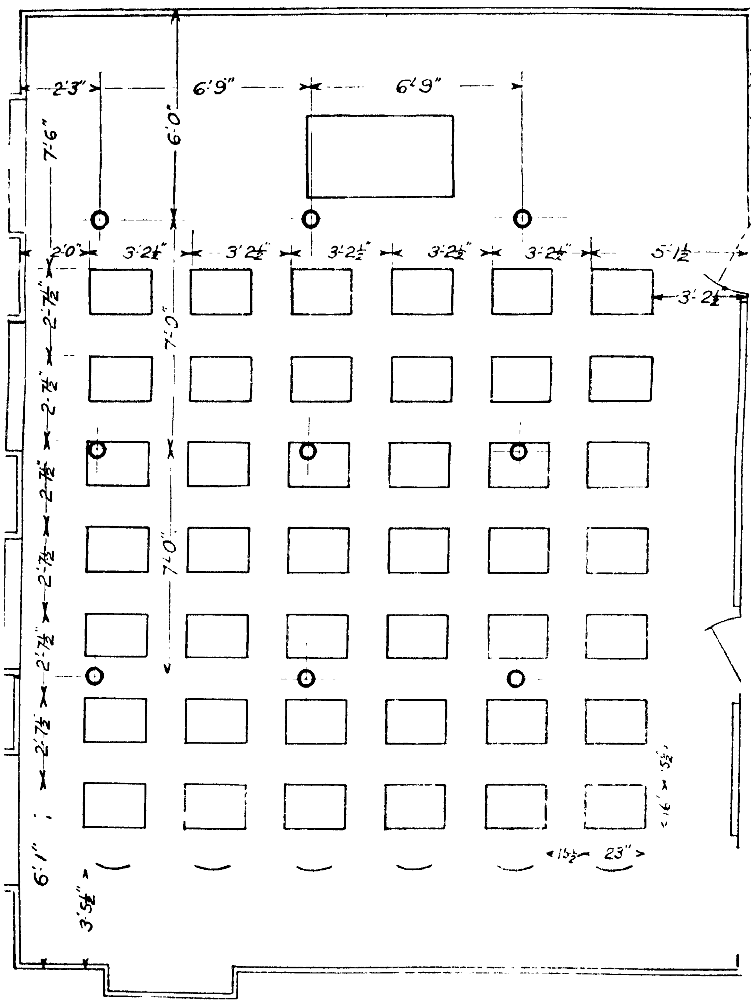


FIG. 10. Tungsten lamp, shade, and supporting fixture. A good light for night schools. From Boston School Document No. 11, 1907. By permission of the School Board.

Acetylene for Country and Village Schools. In villages and country districts not yet supplied with an electric lighting system, acetylene lighting has proved very helpful. This gas, which is made by bringing calcium carbide into contact with water, gives when lighted a brilliant white light and burns quite regularly. It is not expensive to install such plants, and where a comparatively cheap and a very effective gas illuminant is needed, this form is to be recommended. It has, however, the disadvantages and most of the dangers of such luminants.

Conclusion from Experiments in Boston. The experiments of Mr. Hatch referred to above appear in the report made by a special committee appointed to consider the matter of artifical illumination of schoolrooms, and their color scheme. This committee was composed of three oculists and two electricians, and their report is a model worthy of imitation. They give as a part of their conclusions touching the general subject of artificial illumination the following points: —



PLAN OF STANDARD SCHOOL-ROOM, SHOWING LOCATION OF LIGHTS.

FIG. 11. — From Boston School Document No. 14, 1907. By permission of the School Board.

"The committee is of the opinion that for schoolroom lighting there are certain serious disadvantages inseparable from systems in which indirect light preponderates.

"(1) Indirect light produces the unfortunate psychological effect of insufficient illumination.

"(2) Recently published experiments in the *Illuminating Engineer* of October, 1907, point to the fact that with indirect illumination the amount of light for comfort in reading must be 65 per cent greater than with direct.

"(3) Indirect light is an abnormal form of lighting, seldom or never to be found in nature, to which the eye is unaccustomed.

"(4) With it we lose the shadows by which we judge distance and relief.

"(5) The illumination of surrounding objects and that of the work on the desk are the same, while experience has shown that, whereas it is unwise to light the work greatly in excess of surrounding objects, a small amount of superior illumination makes for comfort.

"(6) It is conceivable that light reflected from the ceiling and colored surfaces may undergo some change interfering with its efficiency.

"It will be seen that the problems presented are many and difficult, but the general requirements for schoolroom illumination may be summed up as follows: —

"(1) The light should be produced with as little contamination of the air as possible.

"(2) The heat production should be low.

"(3) The light should not be rich in the rays of the spectrum which are irritating to the eye.

"(4) A steady light is indispensable and the lamps should not be subject to rapid deterioration.

"(5) The light should be well diffused so as to secure uniform illumination throughout the room.

"(6) It should be properly shaded so as to prevent points of great brilliancy from coming within the field of vision, and to avoid annoying and disturbing shadows from falling on the work. For this latter purpose the proper location of the fixtures is of the greatest importance.

"(7) The amount of light necessary varies according to the purpose for which it is required. More is necessary for fine work than for the ordinary class exercises.

"(8) The cost of installation and maintenance should be moderate.

"(9) The fixtures should be of durable construction and easy to clean and repair.

"(10) In considering the color of the walls, the daylight illumination

must be taken into account. For the bright, sunny rooms a very light green is probably the best shade. For the darker rooms a light buff.

"(11) The ceiling should be white or slightly tinted.

"(12) The windows should be provided with shades for excluding the direct rays of the sun and diffusing the light throughout the room.

"(13) The woodwork should be of a light color such as that of natural wood. Under no circumstances are dark walls and woodwork permissible."[1]

Color of the Walls of Schoolrooms. — Some years ago the school board of New York City employed a committee consisting of three prominent oculists to examine the colors of the walls of the schoolrooms in that city and to report to the board recommendations as to the best color schemes to use in schoolrooms to conserve light and to give a pleasing effect. The essentials of this report are here given: "A light buff tint for the walls has proved to be the most satisfactory to the eyes of teachers and pupils. The quantity of light in a room is greatly modified by the color of the walls. The red end of the spectrum should never be chosen in the painting or decorating of schoolrooms, as much light is lost by the employment of these colors. The lighter and most delicate shades of yellow or gray should be chosen. The large percentage of wall space often occupied by blackboards causes much loss of light. For this reason light-colored woods should be selected for the school furniture and for the woodwork used in the construction of surbase, doors, and windows. It has seemed to your Committee that the woodwork in the schoolrooms should have a natural finish with a dull surface, in order to reduce the reflection of light to a minimum, and therefore it should not be varnished. But the superintendent of school buildings, Mr. Snyder, in a letter to the chairman of your Committee, has called attention to the fact that the Board of Health objects to wood surfaces which are not treated in such a manner as to be capable of a thorough cleansing with a

[1] *Report of the School Committee.* Boston, 1907. pp. 5–7.

damp cloth. This objection is valid, and would be difficult to overcome in a nonvarnished surface."[1]

TOPICS FOR INVESTIGATION

1. Measure accurately the gain in light in a school where windows reach to the ceiling, over one where windows are a foot lower, other conditions being equal.

2. Determine by careful observation and experiment whether the statements made concerning the disadvantages of south light for schoolrooms are justifiable.

3. Determine by careful experiment the best color for schoolroom furniture, from the point of view of the hygiene of vision.

4. Devise a simple method of covering up blackboards when not used, so as to determine whether they are really "menaces to the eyes of children," through their power to absorb much light.

5. Would it be well to introduce into our schoolhouse construction greater use of glass in the roofs? Determine the relative cost of such glazing, the advantages and disadvantages to the children.

6. How may we overcome the persistent refusal of many architects to locate the windows in our schoolrooms properly?

7. Determine by experiment the value of prism glass for hallways, basement rooms, and other parts of buildings, frequently poorly lighted.

8. Determine the comparative effects of illuminating a schoolroom for night classes, by the use of the different kinds of illuminants, such as gas and electricity, with the various sorts of burners and globes in use.

SELECTED REFERENCES

BURNHAM, W. H. *Outlines of School Hygiene.* Pedagogical Seminary, v. 2, pp. 9–71.

MARSHALL and ROLPH. *Artificial Lighting of Schoolrooms.* Illuminating Engineer, v. 3, pp. 258–264.

ROWE, S. H. *The Lighting of Schoolrooms.* New York, 1904. 94 pp.

STANDISH, MYLES. *Artificial Illumination of Schoolrooms.* School Hygiene, v. 1, pp. 74–78.

[1] *Educational Review*, Vol. 15, pp. 98–99.

CHAPTER V

SCHOOL DESKS

THERE has been so much written on the hygienic requirements of school desks that one feels loath to attack this question, especially when he sees that, while much progress has been made, some fundamental requirements have scarcely been touched.

The Chief Defect of School Desks. — It seems an indisputable fact that the chief, or at least the most serious, defect of the average school desk is that it subjects the pupil to a posture that fosters spinal curvature, cramped chest, and defective vision. It is proper, therefore, to go at once to the major defect and, if possible, determine what it is and how to remedy it.

Desks are too Flat. — I believe the chief defect in the desks now on the market is that the desk top is too flat. I know very well that this thesis must be upheld by good reasons, or it will fail of acceptance. May I ask the reader to perform a simple experiment at this point, so that he may have at hand some personal experience upon which to base his final conclusion. Find a comfortable chair, one in which you may sit erect but not unnaturally so, and then hold a book before you in such a position and at such a distance that you may read the lines most clearly and easily. After finding the position of the book as you prefer it, note the distance that the page is from the eyes (I am assuming that the experimenter

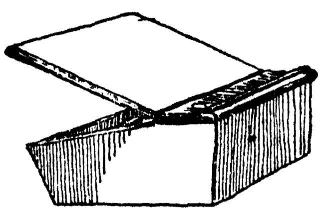


FIG. 12. — Top of the desk shown in Fig. 13.

has normal vision) and the angle that the page makes with the line of vision, that is, the straight line drawn from the eye to the book. After conscientiously recording this distance and this angle for yourself, try the same experiment with all the pupils of your class. Have them sit in a natural and comfortably erect position at their desks. Then ask them to hold their books in such a position that they can read most readily and easily, and then, while they are so situated, note, again, the two points above mentioned. This may be quickly done by moving down a side aisle and noting the regularity of the demands made on the position of the book. Note especially the relative slants of the books and the desk tops. Assuming that the experiment has been carried out as directed, the result may now be definitely stated: the books will practically be at a right angle to the line of vision, and at an angle of slightly more than forty-five degrees to a line parallel with the floor, and approximately fifteen inches from the eyes of all who have normal vision. And now you ask, what do these facts mean, and what have they to do with the hygiene of school desks?

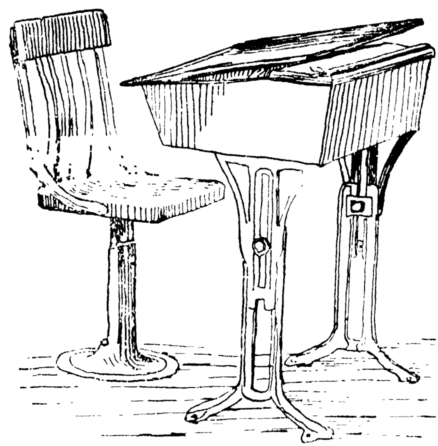


FIG. 13.—Adjustable chair and desk. One of the best American desks.

Unless desk tops are set at the proper angle, children will not, and cannot, sit erect to do their work. Theoretically, one

might say that if these are the normal demands for vision, children should be taught to hold their books so. But suppose you try it for ten minutes or a half hour. Of course you will now see where the difficulty lies. Children's arms grow weary and they cannot hold their books so as to get the proper angle of vision for more than a very short time. So the books are put on the desk, and the children's backs are bent, in order to bring the line of vision in the same relative position as it was when they sat erect and held their books in the position demanded.

Fig. 14.

You may command them to sit erect as often as you think of it, but they will obey, and can obey, only momentarily. The children will bend over their work day after day, unless we devise a practicable desk top that will *necessitate* erect, normal posture for all their work. In other words, if we expect to teach our children to habituate themselves to the proper posture in school, we must adjust their desk tops, or some other means of holding their books, at an angle of approximately forty-five degrees with the floor line. In addition, the desk must be made in such way that the book can be brought within fourteen to sixteen inches of the eyes and yet rest on the desk. This must be done, or the pupil will have to lean forward, away from the support of the back of the seat. Here, then, are two fundamental conditions for a hygienic desk, and before we have any right to expect children to maintain the proper posture in school, we must overcome the difficulties suggested in making such a school desk. How often a boy will slide down into his seat, rest his head on the back of the bench, and stand his book erect on the front edge of the desk. It is easy to call him thoughtless and to command him to sit erect, possibly to reprimand him in some more or less severe way; but the fact is, the boy is really trying to overcome the difficulties and de-

fects in the desk furnished him. The fault lies not with him so much as with the demands that we make upon him.

What has been said concerning the use of the book in its relation to proper posture will largely apply to written work. If the pupil writes on a flat desk, he will stoop over, for he cannot see his work most easily unless he does so. A teacher may command and exhort her pupils to maintain a healthful posture and they may attempt to obey, but as soon as their attention is withdrawn from their posture to their work, the faulty position will again unconsciously reappear, because the demands of clear vision are more persistently commanding than the advice of any teacher.

FIG 15.—A form of steel desk.

Practical Difficulties. Of course the construction of such a desk is difficult even if hygiene requires it. The first criticism every practical teacher would present on this theoretical desk is this: "The books and the papers would slide off the desk." This criticism strikes at a real difficulty, but some one must overcome it, or we shall never have what can be properly called a hygienic desk for school children. Add to this another criticism: "It would be difficult to write on a desk top so steep as the one suggested, because the ink would not flow properly from the pen." Frankly, this is another practical difficulty, but it must be overcome, else children will persist in bending over their writing work to the detriment of

natural, normal development. Is it possible to make a school desk to meet these fundamental requirements?

The Writing Desks of Ancient Scholars. — Before printing was invented, and for many years afterward, practically all the books written were copied and recopied by the monks in the various monasteries of Europe. This was the day of the most artistic pen work that the world has ever seen. Day after day scholars and copyists wrote and illuminated the books of the Middle Ages from the manuscripts of ancient times. Pictures of the desks that they used indicate to what extent they had to develop the form of desks to make it possible for them to do this work, even "for the glory of God."

Let us study the desk shown in the accompanying cut (Fig. 16). It represents St. Matthew writing his gospel as dictated by the Holy Spirit, here represented as an angel. It is taken from a photograph of an illuminated page from a Bible, and was drawn by a French monk about 1460. The original is now in the author's possession, and is one of the excellent examples of illumination. The photograph gives no adequate conception of its beauty, for its rich coloring and delicate decorations cannot be reproduced. But its chief interest in this connection lies in the illustration of the desk. Note first that it would be next to impossible for one to write at this desk without sitting erect. The angle that the board makes with the seat of the chair is approximately fifty degrees. Note the string fastened to the board and the chair post to regulate this angle and to hold the board in place. The scroll hangs over the board and there are weights to hold it in place. The inkhorns are placed on the right side, and everything connected with the drawing indicates that it was made to represent a real writing desk. If the reader is in doubt at this point, and has access to John Willis Clark's interesting book entitled *The Care of Books*, he will find a number of reproductions representing such desks. Nearly all of these show a slant of the desk top equal to the one in the cut here

FIG. 16.—A writing desk used by monks of the Middle Ages. From an illumination made by a French monk about 1400. It represents Matthew writing his gospel.

presented. I made a somewhat extended study of illuminations of like character in Germany, England, and France, and I am sure that this one is quite typical.

I have introduced this cut and the discussion concerning it to show that flat desks are not old but new, and that written work may be well done on these slanting desks, for, as remarked above, the best writing that the world has ever seen was done on them and done with pens not as good as those we have to-day.

Does Rapid Writing require Flatter Desks than this One? — It may be urged as another objection that a desk with a slant of forty-five degrees would necessitate slow writing. Probably there is an advantage in rapidity in writing on a comparatively flat surface; but this seems of slight importance in teaching children to write. There is slight need now for rapid penmen since most business correspondence is done with typewriters. The stenographer must learn to write rapidly, but his writing is of an entirely different character. Besides, it is not clear that even these prefer a flat surface for their notebooks. The stenographers of the United States Congress often do their rapid work while standing, holding their notebooks at the angle that I am demanding, and generally use pens.

Good Writing with a Pen may be done at this Angle. — There is no doubt that good writing may be done with a pen at an angle that will require the pupils to sit erect. However, most of the written work in school is done with a pencil. The average program does not devote more than twenty to twenty-five minutes a day for each pupil above the first grade for writing with pen and ink, and that amount is usually left off after the sixth grade has been reached. It is true that the writing of ancient times was more like the print of modern times, for it was neither so cursive nor so slanting as modern script. It was more like what is now known as vertical script, with less attempt at spacing and connections. This

may or may not be a real objection, for there are many specialists in school hygiene who maintain that oval vertical writing is better for children than a slanting angular script. One thing is true, it is much easier to read, and necessitates a better posture than slanting script.

In free-hand drawing, it is always better to have a desk top with this slant than a flat one or one with ten or fifteen degrees slant. The easel at which the artist works is always at a greater angle than forty-five degrees.

Other important requisites for school desks are the following:—

The Desk Top must be at the Right Distance from the Eyes. — If the desk is too low for the pupil or too far removed from his body when he sits properly resting against the back of the chair or seat, then he will have to bend over, or move forward so as to adjust his vision to the work in hand. It has been given as a general rule that the desk top must overhang the front of the seat about two inches. This rule will hold true only when the seat is the proper width from front to back, and when the desk top has the proper slant.

Plus and Minus Distance of Desk Top. — This position is technically known as minus distance. That is to say, if a vertical line be dropped from the edge of the desk top nearer the pupil, it ought to strike the seat about two inches from the outer edge. If it fell to the floor without touching the front edge of the seat, it would mark a plus distance. This is an important rule and, even with a desk not of the proper slant for school children, great care should be taken to set them for a minus distance. It is safe to say that in most villages and country schools this rule is seldom followed, simply because no one who knows is ready to supervise the placing of desks. Janitors or carpenters should be instructed on placing desks, but they are rarely so instructed.

The Height of the Desk Top from the Floor. — The proper height of the desk will depend on two conditions: the height

of the child and the support for the child's feet. In some European countries, notably Germany, a platform under the benches serves to lift the children's feet above the floor. In America it is a general rule for the benches to be made so that the child's feet may rest on the floor, and we may count on this as the basis of measurement.

A safe rule for teachers to follow in determining the proper height of the desk top for a given child in elementary grade is to make the front edge as high as three sevenths the height of the child, plus an inch. For the primary grades the rule requires that not more than a half inch be added. This will give approximately the right height, but this ratio must be varied to suit special cases, as some children are not of normal proportion in relative length of limbs and trunk. If a teacher will send her class to the blackboard and direct each child to write his name higher than the level of his head, and then face about, standing erect with heels against the wall, she can pass along quickly, making a mark on the board under each name and on a level with the top of the head, and by measuring the height of the pupils, the proper height of the edge of the desk top above the floor may be approximately determined for each. This may be done as many times through the year as the growth of the children would necessitate. It ought to be done at least four times, for it will require little time and will serve to prevent carelessness on this important point.

Adjustable Desks. — Some teachers, indeed most teachers in rural schools, will not be able to follow the rule for height of desk top for the simple reason that the desks furnished cannot be adjusted. Most rural schools are furnished with not more than three sizes of desks, and if these do not fit the pupils, little can be done. It is an advantage for rural teachers to make these measurements, even though they may know that the benches are not adjustable, and are not of proper sizes to suit. They will in this way become conscious of what they

need and will not only strive to make the best assignments possible with the desks at their disposal, but, consciously or unconsciously, they will strive to get better desks furnished, and they will know more definitely what they need.

All Desks and Seats should be Adjustable. — All desks and seats of the better grades are now so constructed that each may be adjusted in height independently of the other. This gives the teacher a chance to make such adjustments from time to time as the growth of the child may demand. Moreover, it makes it possible for all children, whether typical or atypical, to be fitted with desks and seats suited to their needs. This necessitates that the seats should be disconnected from the desks; otherwise, the proper adjustment of the seat for one child might disarrange the desk for the pupil who sits immediately behind him. If a seat is fastened to the desk behind, it introduces another trouble. Every movement of the child in front tends to interrupt by jarrings and shakings the work of the child behind. For several reasons it is, therefore, better to have the desks and seats built separately, so that each may be adjusted independently.

FIG. 17. A popular form of a German desk, which is designed for use sitting or standing.

Height of Seat above the Floor. — The old-time school bench was made of a split log adzed comparatively smooth on the flat side and set on pegs, had no back, and generally the pegs

were too long to accommodate the bench to the children in a proper way. Pupils in those days sat with their feet out of reach of the floor, and these difficulties have not been wholly remedied. Great numbers of modern children, while not sitting on split logs without back rests, are still suspended on high benches. While this condition is, I believe, rapidly disappearing in those communities that employ well-prepared teachers, other communities need enlightenment in this regard. It is obviously very tiresome for a child — and all children weary easily — to have no suitable and proper footrest. The weight of the lower part of the limbs will prevent proper circulation, will tire the muscles and will inevitably render the child's position unstable and irksome. Furthermore, in exaggerated cases the thigh bone becomes bent and may develop abnormally as a result. The pupil's feet should rest easily and flatly on the floor, so as to remove all undue pressure upon the under side of the thighs next the knees. If seats are even slightly too high, the pupil will sit on the edge of the seat, in order to avoid fatigue. Such a position impedes circulation, takes the child away from the back rest, and usually causes him to lean over on the edge of the desk top.

Fig. 18. — The same as Fig. 17. Pupils standing.

The proper height of a seat is approximately two sevenths of the height of the child; but it may be determined more exactly by measuring the distance from the under side of the knee to the floor, when the child is sitting in a normal, easy posture. In the country, children often go to school barefoot in the summer. This will make a difference of about half an inch in the proper height of the seat, from that needed in winter, when shoes are worn. These differences ought to be noted, and the rightful adjustments made.

FIG. 19.

In all cases it is not only harmful to the proper physical development of children to require them to sit on benches or chairs too high or too low for them, but it is downright wickedness to subject them to such inconveniences and pain.

Proper Shape of the Seat of a School Bench or Chair. The seat board ought to be wide enough for the lower limbs, when flexed in the sitting posture, to clear the edge comfortably and for the back to rest against the back of the seat. If the seat board is too wide, it will crowd the child forward and will inevitably cause him to lean over in order to rest on the edge of the desk top. If too narrow, the weight of the body will be supported in such a way as to impede the circulation Generally speaking, however, I believe that the seat boards are more often too wide than too narrow. The seat board should be hollowed out slightly next to the back rest, so as to keep the body from sliding away from the back rest, and to distribute the pressure more evenly. The outer edge of the seat, for an inch or two, should be slightly convex from above, and rounded at the extreme edge. The curve of the seat board should vary, especially for the upper grades. Adolescent girls need this more than the boys.

FIG. 20.

Shape and Height of the Back Rest. — Here, again, the average school bench or chair now on the market is, I am persuaded, rarely correctly made. The back rest ought to so fit the back as to give it just that support it needs when the proper posture is taken. The backs of the boys are not the same shape and proportion as those of the girls, especially in the upper grades. The back of the normal boy has less forward curve as he sits in the proper way than the back of the girl. Especially is this true in the adolescent period. Due to the fact that there is a deposit of adipose tissue in the gluteal region of well-developed girls, the small of their backs is crowded away from the back rest more than is true in the case of the boys. How often have you seen the older girls rest their backs against a book put against the back of the seat at the waist line! Here is just where the back fatigues most quickly, and here is just where it needs the most support. The waist line of rapidly growing adolescent girls rises rapidly above the seat board, and a few months is often long enough to show a marked change. In some way this phase of the hygiene of school benches has been sadly neglected. The back of the bench ought to fit the back of the child at each stage of its growth so that when the proper posture is taken, support will be afforded. This is especially important for the girls, and I believe when accurate examinations are made that a larger number of girls will show scoliosis (lateral curvature of the spine) than of boys. Boys have more opportunity, or at least take more opportunity, for outdoor sports and games than the girls, get more vigorous physical exercise, and in this way they generally correct the effects of faulty posture maintained during school hours.

Curvature of the Spine. — For instance, among those who have been treated in the famous Copenhagen Institute for Cripples, nearly four times as many females were afflicted with scoliosis as males. This, of course, does not mean that all of the discrepancy was due to improper benches or chairs;

but it does indicate that girls may be more susceptible than boys to spinal curvature. This may be due, in large part, to the possibility that girls are apparently more inclined to rickets, induced by poor nutrition in early childhood.

In a published article[1] D. C. McMurtrie gives a table that shows the distribution of cripples according to deformity; and in this we learn that of one thousand nine hundred and thirty-two children showing this defect, one thousand five hundred and twenty-eight were girls and four hundred and four were boys. Practically the same percentage holds for adults. This evidence is, of course, not conclusive, for conditions may operate to bring into such an institution a greater proportion of girls so affected than of boys. The number of cases is far too small from which to draw general conclusions.

Dr. Esther Parker says: —

> "More than one third of the women I examined last fall showed curvatures varying from slight to marked cases." In her discussion of these facts she says: "If we could induce mothers not to corset their daughters so early; and to be more careful about the size of the heels of their shoes; and if we could influence school superintendents to have school desks adjustable to the size of the student; and if growing muscles were given freedom of movement instead of being trained to keep still, we could hope to reduce the number of spinal curvatures."[2]

Lateral curvature of the spine due to faulty posture may be overcome in children by judicious guidance in those setting up exercises that tend to produce correct posture and normal carriage. But organic or structural lateral curvature demands more specialized treatment. Drs. Lovett and Sever classify severe cases in childhood as due to one of the five following causes: —

[1] *The Copenhagen Institute for Cripples, Its History, Work, and Results.* Boston Medical and Surgical Journal, Nov. 23, 1911, pp. 794–798, Vol. 165, No. 21.

[2] *Physical Condition of Women during College Life,* Dr. Esther E. Parker, Physical Examiner and Medical Adviser of Women, Cornell University, in Buffalo Medical Journal, Vol. 67, No. 12, p. 668, July, 1912.

"(1) A congenital anomaly of the spine, such as split vertebræ, etc., a class of cases only recently recognized as so important; and until the use of the X ray not generally understood.

"(2) Infantile paralysis.

"(3) Empyema (an accumulation of pus or other fluid in some cavity of the body)

"(4) Rickets.

"(5) A softness of the bones which we must assume without direct evidence of rickets."

The treatment advocated in these organic or structural cases of lateral curvature is that of " forcing the spine into a normal position, and holding it there during part of the period of growth " by removable jackets; and to utilize the recumbent position as an aid, along with proper gymnastics, to restore the muscles to their normal support.[1]

The Height of the Back Rest. The height of the back of school benches is generally too great. It has been determined with a reasonable degree of certainty that if the backs of school benches or chairs be just a little lower than the shoulder blades of the pupil when sitting properly, the best results, other things equal, may be obtained. Such a height prevents the shoulders from crowding the body forward, permits the back to receive the support where it is most needed, gives freedom of movement, and prevents to some degree the tendency to slide down in the seat, though, as explained above, this tendency is chiefly due to the faulty construction of the desk top.

Movable Chairs instead of Ordinary Desks. Due to the movement for a more general public use of schoolrooms and also to the growing desire to make the schoolroom a more convenient place for active school work, with a less rigid daily program and more freedom in classification, movable school chairs with attached box for books not in immediate use, and

[1] See *The Treatment of Lateral Curvature of the Spine* (illustrated), by Drs. Robert W. Lovett and James Warren Sever. Mind and Body, Vol. 18, November, 1911, pp. 281–290.

a tablet fastened to one side, have recently been introduced into some parts of the country. The Moulthrop school chair, represented in Fig. 21, is one of the most successful of these chairs. There are some advantages in the use of such chairs, as any teacher may readily see. The chief disadvantage is the fault already pointed out in ordinary desks. The tablet upon which the books and writing material must rest is too flat, and is not readily adjustable to the demands of normal vision and hygienic posture. It may be, however, that this chair is the forerunner of simpler, less expensive, and more hygienic school furniture.

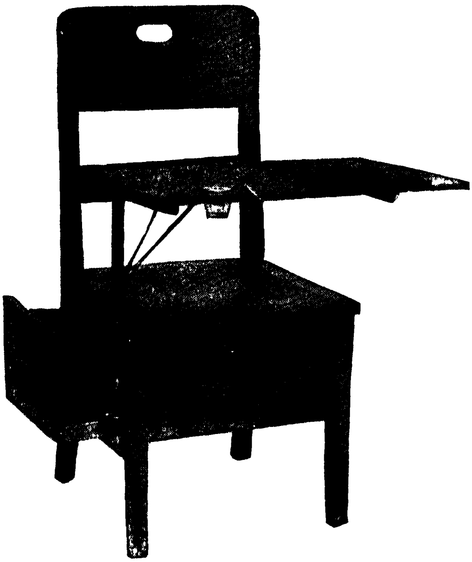


FIG. 21. — The Moulthrop school chair and desk combined.

TOPICS FOR INVESTIGATION

1. Have your pupils stand facing the blackboard in a natural, erect posture, and note which of them, if any, have apparent lateral spinal curvature. Note which shoulder or which hip seems higher, and to which side the spinal column bends. Such an examination will be of little service save to aid in picking out subjects for more careful individual examination, but it may be of signal service to some.

2. Measure the height of all your pupils and determine how closely the rules given above for approximating the height of the seat and that

of the inner edge of the desk top will meet the normal requirements of each pupil.

3. Study the position of each seat and its desk to see whether or not they are properly adjusted to a minus distance.

4. Study the postures of pupils while they are at work in order to determine as accurately as possible what conditions of the pupil and desk make unhygienic postures so common.

5. Note the shape of the backs of the older girls and, if possible, devise some means of relief to those whose backs get improper support.

6. How can you vary your daily program so as to afford the relief from long sitting in cramped and unnatural postures, that the health of the children demands?

7. At a certain period each day for a week or two, count the number of children in your room who, without previous correction, are sitting in a good position, and with a good posture.

8. What advantages and disadvantages would accrue to your school if instead of the ordinary fixed benches and desks your pupils were furnished with chairs and tables properly constructed, so that they might gather in groups to do their work?

9. Study the arrangement and location of your desks, and if they are not properly set, relocate them on a floor plan, and ask the authorities to replace them for you.

10. Somewhere in your schoolroom have a writing desk whose top may be adjusted to various slants, and determine what can be done to make hygienic demands and practical necessities coalesce.

11. Determine the best method and position of placing ink wells in school desks.

12. With the aid of each pupil make a careful description of the condition of his desk at the beginning of each term, so that each one may be justly held responsible for any rough usage of his desk.

SELECTED REFERENCES

Boas and Wissler. *Statistics of Growth.* Report of U. S. Commissioner of Education, 1904. pp. 25–132.

Bobrick, G. A. *Hygienic Requirements of School Furniture.* New York, 1892. 51 pp., illus.

Hartwell, E. M. *Report of the Director of Physical Training.* Boston School Document No. 4, 1895.

Lovett, R. W. *Lateral Curvature of the Spine and Round Shoulders.* Philadelphia, 1912. 192 pp., illus.

(See various texts on school hygiene for further discussion.)

CHAPTER VI

SCHOOL BATHS

The Need of Baths at School. — If all school children, or even if the large majority of public school children, were supplied with proper bathing facilities at their homes, it would be inadvisable to make any provision for baths in school buildings. But to those who are too poor or too careless to supply baths for their children, the schools must give this help, or else these children will grow up with filthy personal habits, and disrespect for cleanliness in general.

While bathing facilities in apartment houses and "flats" in the larger cities are now usually supplied, the cheaper houses for workmen are oftener neglected. In the smaller towns and in the country the bathtub is altogether too rare. No one can give even an approximate estimate of the number of school children who are accommodated at home with regular bathing facilities; but it is safe to say that not half of the children in cities regularly bathe at home, while in the country the percentage is discouragingly small.

School Baths needed for General Sanitation. — School baths have proved their value not only as a means of teaching children the need and joy of individual cleanliness, but they have materially aided in keeping the atmosphere of schoolrooms purer and rendered infection far less likely. To those who have not come into intimate contact with the habits and customs of the varied population represented in our public schools to-day, it may seem almost unbelievable to say that it is not at all uncommon to find boys and girls sent to school "sewed up for the winter." Such unhygienic care of children

has come to light since school baths have been established, and has emphasized, in a striking way, the necessity for demanding them. It has never been necessary to make school bathing obligatory, but simply to require of each child at least one bath a week either at home or at school. Such a regulation gives the parents an option, and in this way prevents useless friction. Experience has proved that parents who would otherwise object to compulsion have acquiesced, and the children have often preferred the school bath to the home bath, even where suitable home facilities are afforded.

Shower Baths the Cheapest and Best. — Shower baths are more suitable in schools than tub baths or swimming pools. They are far less expensive both to install and maintain, and are more sanitary. A shower requires much less water, less space, less time for the bath, and affords a minimum opportunity for contagion.

Methods of installing Showers. — Shower baths for the primary and lower elementary classes do not require individual booths. Instead of these, a series of shallow cement basins can be constructed in the floor of a well-lighted and well-ventilated basement room, the sprays arranged above to supply the bathers, and exit drains made from the bottom. Or better still, the whole floor could be built of cement or impervious tiles and made to slope slightly toward a central outflow, and the sprays hung from the ceiling to accommodate a whole class of boys or girls at once. Dressing booths in a neighboring room will thus permit the children to disrobe, and put on thin bathing trunks. A large number may bathe at once, thus securing regularity, supervision, and helpful directions. Such an arrangement will also enable the attendants to note the general physical condition of the children and to exclude any who may show signs of disease or weakness, that would render a bath inadvisable. By this method all the boys or all the girls from a classroom can easily bathe in from twenty to thirty minutes, at a minimum cost, and under very whole-

some conditions. Individual booths with showers are necessary for the older pupils.

Influence of School Baths on the Home. — The first opposition to school baths was made on the theory that the school had no right to encroach on the duties and privileges of the home, and that it was a form of school paternalism more or less socialistic in its nature. Moreover, it was claimed that it would bring about greater neglect of children at home. Experience has proved that these objections were not well founded. The instinctive pride that causes a mother to shield her children from criticism has operated in the case of school baths to cause her to keep the children's underclothing cleaner and in better repair. It has, in some measure, caused parents to give more attention to general physical cleanliness and well-being. Besides, the children who have benefited from school baths have carried back to their homes a gospel of purity and preached it to the resulting good of the whole family. They are thus being prepared to demand in their own homes, present and future, more wholesome and sanitary conditions. Those parents who, through ignorance or moral obliquity, have hitherto neglected their children have been compelled to submit to the rules and to give their children the opportunities that health and general cleanliness demand.

School Baths needed in Towns and Rural Communities. — Aside from the poverty-stricken, congested centers of our large cities, school baths are especially needed in the town, village, and rural schools because a large percentage of children who attend these schools rarely get a really hygienic bath. But the objection will be urged at once that it is practically impossible to install baths in these schools, both on account of the expense and the lack of running water. These are real difficulties, and it will take faith and much labor on the part of those who are striving for better things to overcome them. It is now possible, in connection with windmills, gasoline, electric, or even hand-driven force pumps, to install

a pressure tank water supply in all public schools. (See Chap. VII.)

Essential Requirements of School Baths. — The rooms should be well lighted, thoroughly ventilated, and properly heated. The walls should be made of cement and faced with white glazed tile or brick. The floors should be of cement or cement and nonporous tile, and the ceiling of cement finished with a light-colored waterproof paint. The fixtures should be simple and inexpensive and scientifically set. Some safe and effective method of heating the water should be installed in connection with the general heating system. Where natural or artificial gas is available, this is not at all difficult. The water should be pure and clean and the drainage from the building ample and sanitary.

Swimming Pools. — In general, swimming pools in connection with public schools are too expensive to construct and maintain in proportion to the good that they accomplish. Unless they are extensive enough to accommodate a large number of pupils at the same time, it is difficult to arrange an economic program for their use. They require a great amount of water, introduce some dangers, and require much labor to keep them wholesome. They do, however, furnish opportunity for good exercise and fine sport. Where they are well constructed, of ample size, and hygienically kept, they can be of great service, especially to the younger children in teaching them to swim. They are effective in connection with evening schools, continuation classes, or general social work on the part of the school.

TOPICS FOR INVESTIGATION

1. Under what conditions would it be possible to install shower baths in rural schools, and to arrange a regular program for bathing?

2. Do you think it advisable to undertake to furnish free shower baths for school children in cities? In towns? In the country? Give satisfactory reasons for your answer.

3. Make a careful study of the history of school baths, their advantages and their disadvantages.

4. Why are shower baths much to be preferred to other kinds of baths for schools?

5. Under the conditions at your school would it be better for the schools to furnish soap and towels for the baths, or should the children bring these from home on the days needed?

6. Devise a bathroom for rural schools.

SELECTED REFERENCES

GERHARD, W. P. *Modern Baths and Bathhouses.* (See Chap. 10.) New York, 1908. 311 pp., illus.

Report of Educational Commission London County Council. 1906. 23 pp.

ROSE, F. *The Use of Shower Baths in Schools in England and on the Continent.* London, 1906. 24 pp.

CHAPTER VII

CONVENIENT AND SANITARY WATER SUPPLY FOR SCHOOL BUILDINGS

The Water Pail in Schools. — Little effort will be required by those past the meridian of life to recall the days when a wooden bucket and a tin dipper were the only visible means of supplying thirsty country school children with drinking water. Either two boys were given the much-sought-for privilege of carrying water during school hours — it wouldn't be fun at any other time — from a neighboring well or some distant spring, or else the teacher went to school early enough in the morning to prepare for the demands of the day. At best, as one looks back to those days, he cannot help recalling the slimy bucket, the sloppy floor, the rusty dipper, and all the other features incident to this primitive and filthy method of supplying water. Later, wells were dug and, while in some instances these gave much relief, in other cases they were left uncared for and eventually became a source of danger more pronounced than the common water pail.

The City Water System. — When a system of waterworks was installed in towns and cities, the schools quickly took advantage of the supply thus offered, and the problem then became one of supplying the children promptly and with decency. Meanwhile, the rapid strides made in hygienic science brought to the attention of those in authority the danger from common drinking vessels, and, as a result, we now have drinking fountains where the children may drink quickly without danger of contagion unless the water is from an impure source. But country and village schools, because of their isolation from any system of waterworks, have struggled along with buckets and wells, or have depended on some neighboring spring.

The Pressure Tank System of Water Supply. — One of the urgent problems, then, of village and country schools, especially in the case of the smaller high schools, is that of an adequate and convenient supply of water for drinking purposes and for laboratories, toilets, baths, and lavatories. This problem is now in the process of solution, and in fact has been practically solved so far as appliances go. Country and village schools can have a safe and sufficient water supply for all of these purposes, and will have as soon as public opinion is sufficiently informed in regard to these matters. For many years windmills with an open tank placed high in the framework supporting the mill have been used on farms; but while these tanks have served well enough for barnyard purposes, on account of storms, freezing weather, dust, and other sources of contamination, they have not proved generally successful for household use. The air pressure tank, a comparatively recent invention, is now superseding this outside tank, and by reason of the fact that it may be placed in a basement or buried in any convenient place below the frost line, and is wholly isolated from all sources of contamination, if the water supplied is pure, most of the objections referred to above have been removed. For example, a deep-driven well tapping a water supply below the danger line of infiltrations can be sunk in many school lots, and will supply purer and safer water than can be supplied by most of the city water systems. The water from such a well can be raised and forced into the pressure tanks by a windmill, a gasoline engine, or, where electricity is obtainable, by a small electric motor. The former is less expensive, but is in general not so reliable as the others, and is also unsightly, noisy, and frequently troublesome.

The plumbing in either case may be arranged to meet all of the demands. Running water can be provided wherever it is needed, inside or outside the building. The principle involved in such a system is simple. A strong, air-tight steel tank of the capacity required is installed in the basement

where it will be safe from frost. This is properly connected by a water pipe with the force pump run by the windmill or the engine. An air pump generally worked by hand is attached to the tank so that a sufficient amount of air may be kept in the tank. When the water is pumped in, it will compress this air, which will force the water through the service pipes with a force equal to the pressure exerted, minus the necessary friction of the water as it flows through the service pipes.

Naturally the water pipes enter the tank from below and the air occupies the upper part of it. A pressure gauge indicates the force and denotes more or less accurately the amount of water available. If the room in the basement is needed for other purposes, the tank can be run through an opening in the foundation wall well below the surface of the ground. This will give opportunity to make repairs, changes, or to stop any leaks in the pipes. This arrangement keeps the water at about the same temperature winter and summer, a consideration much appreciated in cold as well as in warm climates.

It will also readily occur to all school men that such a system will not only deliver water for toilets, baths, laboratories, and for drinking purposes, but will give protection against fire, and will make it possible, even in dry weather, to keep a school garden in good condition. There are a number of manufacturing establishments ready to make plans, and to submit specifications for installing such a system.

This method of water supply will furnish the means of solving another vexing problem of peculiar hygienic importance. The outhouses connected with the public schools in towns and country districts have long been menaces to both the health and morals of the children. Open vaults and vile cesspools are now known to be sources from which typhoid and other contagious germs are carried by means of flies into homes and school buildings, and there distributed on food supplies or

deposited directly on the exposed parts of the bodies of the children, whence they are transferred into the alimentary tract. Investigation has shown also that after a typhoid patient has sufficiently recovered to attend school, the excreta may still carry germs, and, in this way, offer opportunity for the spreading of this dangerous disease. But even if these outhouses were not sources of contagion, they are disgraceful and shocking reminders of a time when nothing better could be had. With a pressure tank system of water supply, all schools now have the opportunity to get rid of them. But some one will ask, "How can you get rid of them unless you have a sewer system, and most villages and all country districts are still unsupplied with these means of sanitation?" The answer is, by means of septic tanks and subsurface drainage elsewhere described (p. 129).

Wells at Rural Schools. — Wells at country schools deserve far more consideration than they often get. They are usually shallow, for rather than go to the trouble or expense of sinking a deep well, district trustees will require the school to depend for drinking water on the well of the nearest neighbor or on a spring. A shallow well on a small school ground is usually a menace to health because of surface contamination, or through infection from cesspools or open vaults. During the long vacations the water becomes stagnant, and, unless the walls and casings are unusually well made and tight, small animals, toads, and vermin of various kinds are likely to find lodgment in it. Even if it is cleaned out at the opening of school, and this is not the rule, time will be required to change the water often enough to insure safety. Since cramped school grounds and insanitary privies are far more frequently found at these schools than not, the danger from infection is very great, especially in the fall and springtime.

Wells ought to be deep enough to tap the water supply below a line subject to surface infiltration. The depth to

satisfy this sanitary demand depends on the topography and the opportunities for soil pollution in the neighborhood. If, for example, the school ground is considerably higher than the region about it, there is a tendency for the surface water to flow away from the well. This favors the purification of the water before it has time to sink into the soil and be drawn back toward the well. The nature of the soil through which the surface water percolates may also have much to do with the purification of the water. If the soil about the school premises is porous and not water-soaked, so that the oxygen of the air can sink into it, the saprophytic bacteria contained in the soil quickly render the organic impurities in it inert and harmless. On the other hand, if the ground is comparatively level and wet, these purifying agencies cannot do their work so successfully, and impure surface water must gradually flow from all directions toward the well. If the well is deep enough, or the formation is of such a nature that an impervious stratum can be pierced and the supply of water can be drawn from beneath it, the danger from infiltration may be greatly lessened. This of course depends on the dip of the stratum and the possibility of contamination at the source from which the water is drawn. If the dip of this impervious stratum is such that it comes to the surface at a safe distance from the well, and the source of the water supplied to the area below it is relatively pure, a well drawing its supply therefrom will be safe. But to insure no pollution from the soil above the impervious stratum, the wall of the well must be so constructed as to shut off infiltration from the ground immediately around it. A well thirty-five feet deep, piercing an impervious layer of soil or stone ten feet from the bottom, requires a water-tight wall above this point to shut off the possibilities of seepage into it. Such a wall may be made from glazed sewer tiles set in cement. The top of the well should be arched over and closed so tightly about the pump that neither drippings from the pump, surface drain-

age, nor any animal, insects, or vegetable material can find entrance to the well.

The toilets should be constructed in a strictly sanitary way, and the waste therefrom delivered a safe distance from the well.

TOPICS FOR INVESTIGATION

1. How may school wells be walled and incased so as to prevent surface contamination?

2. If there is a spring in the neighborhood of a country school, how can one be sure that the water is wholesome and free from pollution?

3. Is it possible to install a force pump in a "driven" well at your school, and in connection with this a pressure tank, so that pure running water may be available for all the purposes of a school? How much would it cost?

4. Should there be a well on the ordinarily restricted school lot in the country, where toilets with cesspools are used?

5. How are wells and springs ordinarily contaminated in country districts?

SELECTED REFERENCES

Brewer, I. W. *Rural Hygiene*, Chaps. IV, V. Philadelphia, 1909. 227 pp.

Gerhard, W. P. *Sanitation, Water Supply and Sewage Disposal of Country Houses*. New York, 1909. 328 pp., illus.

Mason, W. P. *Water Supply*. New York, 1902. 448 pp.

Raynes, F. W. *Domestic Sanitary Engineering and Plumbing*. (See pp. 193–339.) New York, 1909. 474 pp., illus.

Richards, Ellen H. *Conservation by Sanitation*. (See pp. 19–168.) New York, 1911.

CHAPTER VIII

DRINKING CUPS AND DRINKING FOUNTAINS

The Danger of Common Drinking Cups. — More faith is required for the average man to believe that dangerous microbes can adhere to an apparently clean drinking vessel, and in this way transmit disease, than was demanded of the ancients for their belief that a salamander was proof against destruction by fire. The microscope and the methods of investigation made possible by its use have revealed a new world to modern generations. This is the world of the unseen, and consequently, to many people, the world of the impossible. It has taken a long time to convince critical people, those who have not had training in bacteriology, to realize and believe. A much longer time will be required to teach the uncritical to make their lives conform to facts so far beyond their power to know at first hand. It is a part of the work of teachers to build up in the mind of the children this faith in science and their willingness to depend on technical and specialized knowledge. There are some facts that most teachers must take on faith, for, in the nature of things, only a few can have the training necessary to know through personal experience.

The ordinary method of washing dishes and drinking vessels does not remove all living microbes from them. Dish water sufficiently cool to allow the hands to be immersed in it will not thoroughly disinfect a cup or a dish, even if the water be clean. Drying with a clean towel will not remove all foreign matter, least of all the almost infinitely small bacteria that are omnipresent. Faith is needed to believe this, even though proof of the truth of it can be set forth in abundance. It has been proved beyond question that tuberculosis may be

transmitted from one person to another through the use of a common drinking glass. The same is true of diphtheria, tonsillitis, mumps, whooping cough, typhoid fever, meningitis (commonly known as brain fever), la grippe, pneumonia, and, in fact, most of the common contagious diseases. Of course this does not mean that these diseases are usually transmitted in this manner, but that they may be so transmitted and often are, especially in public schools.

Suppose that there are children attending school who, although apparently well, are "carriers" of the germs of diphtheria, and suppose a common drinking cup is used by all the scholars. It is not probable that all the children will escape infection. But how can a child be well, and yet be a carrier of diphtheria? Just in the same way that dry dirt may contain seeds from a great variety of plants, and yet give no evidence of their presence until moisture, warmth, and light are furnished. These are conditions for germination. So the germs of diphtheria may remain for an indefinite period in the mouth and throat of a child, only awaiting proper conditions for development, or opportunity for infecting others who are susceptible. During an epidemic of diphtheria in a small city of Indiana in 1911 the State Board of Health of that state found four hundred "carriers," only four of whom developed clinical symptoms of the disease. Two hundred eighty-eight of these were found among the children in attendance on the public schools. In order to prevent outbreaks of diphtheria, it will not suffice merely to isolate those who are ill with the disease, but the "carriers" must be discovered, treated, and guarded as dangerous to the health of the community. In most places this will not be possible at this stage of public sentiment regarding the importance of preventive measures. But certainly it is the duty of teachers to know that even "well" children may become sources of infection, and thus see the means of minimizing, in every way possible, the opportunities for such infection.

Hence common drinking cups, together with common towels and common lead pencils, ought to be banished from schools.

Bacteriological studies have been made of common drinking vessels used in schools, railway carriages, at public fountains, and of those used in communion services in church, and the results have demonstrated beyond doubt that when one person puts even a sterilized cup to his lips, though he use the greatest care, there will cling to it some of the dead epithelial cells of the lips and mouth, and that to these cells cling such bacteria, pathogenic and nonpathogenic, as are inhabiting his mouth at the time. Attention is called to the fact, in the chapter on the "Teeth of School Children," that a very small percentage of the children have been accustomed to the use of the toothbrush, and that the decaying particles of food lodged in the crypts of the teeth offer abundant material for the development of bacteria. A knowledge of the condition of the mouths of school children will not only reënforce the argument for the use of individual cups or of a sanitary drinking fountain, but will convince all teachers that it is inexcusable to compel children with all degrees of mouth impurities to use the same drinking cup. Children must be taught that the most dangerous things to civilized man are not the things that can be readily seen, but those myriads of microscopic plants and animals which are the causes of most, if not of all, of the diseases that attack us. Before the microscope was invented, things were thought to be absolutely clean when the dirt could not be seen. Now we know that the most dangerous part of "dirt" is that which is invisible to the unaided vision. Yellow fever has disappeared from Havana since it was discovered that invisible germs were taken by a certain kind of mosquito from a patient suffering from this disease that, after a period of development, these were transferred to a well person, and that, while there was no direct way to get at the germs, yet if the carriers, the mosquitoes, were killed, there would be no yellow fever. The same is true for malaria.

But many diseases are transmitted directly from person to person, especially diseases of the mouth, throat, and air passages, by the mere transference of the germs from one to the other. Common drinking vessels and common towels are two of the things that we must teach the children to avoid. There are certain districts in the mountain sections of the southern states where trachoma, a most dreadful disease of the eyes, has involved whole families and neighborhoods because these poor people did not know, and could not know, how the infection was carried from one to another.

Many innocent people have been infected, through the use of common towels and drinking vessels, with hideous diseases usually associated with immoral living, and have not only suffered in body, but have been misjudged and degraded in the eyes of men. It is very encouraging to see how rapidly these conditions are giving way. On all the great railroads and in public places generally the common cup and the roller towel have disappeared. Sanitary paper cups, individual towels, and laws against spitting in public conveyances are comparatively recent innovations, but they have already saved much suffering, and are creating in the minds of people a finer sense of fitness and decency.

The following extract from the sanitary code of Louisiana, relative to the use of common drinking cups, will illustrate what is being demanded by health boards in all progressive communities: —

"The use of the common drinking cup on railway trains and in railroad stations, public hotels, boarding houses, restaurants, on steamboats, stores, or any publicly frequented place in Louisiana is hereby prohibited from and after March 1, 1911. No person or corporation in charge of any of the aforesaid places shall furnish any drinking cup for public use in said place, etc., and no person or corporation shall permit on said railroad train, in railroad stations, public hotels, boarding houses, restaurants, steamboats, or any publicly frequented place in Louisiana, the use of the drinking cup in common.

"There must also be posted in a conspicuous place by the individual

or corporation by the drinking water container in any of the places mentioned in foregoing paragraph, a warning cardboard with the above printed thereon in large letters so that they can be easily read."

Drinking Fountains. — Whenever it is possible to have a supply of running water, there is no further excuse for the use of common drinking cups, or even the troublesome care of individual cups in schools. Convenient and sanitary drinking fountains are now available in connection with water jars, or water coolers, where running water cannot be secured. The accompanying illustration, Fig. 22, shows how a fountain of this latter type can be used, thereby rendering drinking cups unnecessary, and at the same time insuring cooler and cleaner water.

FIG. 22. — A form of drinking fountain for rural and village schools. (Courtesy of the Waterbury Company.)

Where running water is available, the sanitary bubbling cup, shown by Fig. 23, will prove especially useful. Such fountains save much time, insure cleanliness, and prevent the spreading of any contagion from child to child through the drinking water. The principle involved in all forms of sanitary drinking fountains is that of furnishing a stream of water bubbling at least two inches above the fixture and of sufficient volume to provide an easy means of drinking without permitting the lips to touch the bubbling cup, or the water which

touches any part of the mouth to fall back into the stream. In selecting a bubbling cup from those now on the market, it will be necessary to take into account the following points: —

(*a*) The cup should be made of material that will neither rust nor corrode.

(*b*) The stream ought to be steady and so well controlled as to prevent the children from squirting each other, or wetting the floor about the fountain. This is an important consideration, for a stream of bubbling water affords a great temptation for the children to dabble and to play tricks on each other.

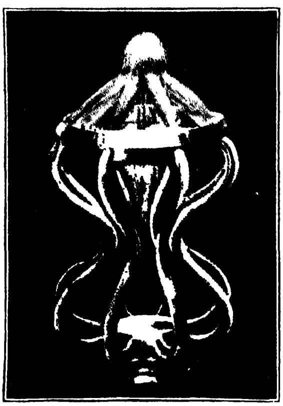


FIG. 23 — A sanitary bubbling cup.

(*c*) The bubbling cup should be reasonably strong and simple in construction.

(*d*) The discharge for the waste water should be so constructed as to prevent clogging with refuse of any sort.

(*e*) The valve should be so arranged as to permit the teacher or janitor to regulate the stream, and at the same time to permit a child to open it whenever he needs to drink. In the latter case, it ought to close automatically when the child has finished.

In warm climates where ice is available, it is advantageous to have an ice box connected with the water supply. This may be made at comparatively small expense by lining the bottom and sides of a nonconducting box with a coil of water pipes or block tin coil so that the ice may be in close contact. The water from the melting ice must be discharged into an outflow and in such a manner as to prevent clogging, and to permit frequent cleaning. In this way water may be cooled

without any danger of contamination from the ice. When a cooler of this sort is used, the water should be allowed to flow from the bubbling cup only when needed.

If by reason of the expense involved school authorities cannot afford to supply a school building with the better class of drinking fountains, fairly good substitutes may be constructed by any plumber by following these general directions. Connect at right angles with the service pipe a piece of ordinary water pipe so as to form a T, and of such length as to afford room

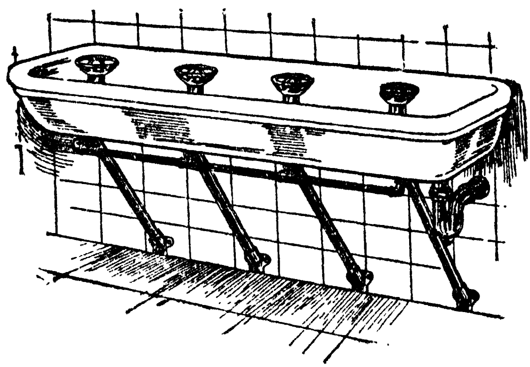


FIG. 24. — A battery of bubbling cups in a basement. (Wolff.)

for the number of bubblers needed. The ends of this bubbling pipe should be closed, and the whole incased in a nickeled covering. Open in it at a distance of about thirty inches from each other small holes through which the water may flow when the valve regulating the supply is open. These holes should not be exactly on the top, but slightly to the front, so that the stream cannot fall back into the opening. The proper size of the holes can be determined only by experiment, for the water pressure in no two water systems is the same. The stream should be controlled by a key valve, so that the teacher or janitor may regulate or close it. There should be a sink basin below to catch and carry away the waste water. Foun-

tains so constructed prove fairly satisfactory in basements, or on playgrounds when the weather is not very cold. They are not satisfactory above the basement.

Location of Drinking Fountains. — The question of location of drinking fountains is often a difficult one to solve. Theoretically they ought to be located near the children when they are most in need of a drink. Were it not for the difficulties due to freezing weather, they would best serve their purpose for the majority of children, if immediately accessible from the playgrounds. Such a location has the additional advantage of preventing congestion in halls or basement rooms after intermissions. In those parts of our country where it freezes seldom, schools with playgrounds should have drinking fountains outside the building, but properly protected from heat and dust. In cold climates they should be located inside. In all cases, however, there should be fountains sufficiently near classrooms, for use during school hours. If put in halls, they should be recessed, so as to be out of the way. If in basements, they should be in the lunch room, or in some room well lighted and sanitary in every way.

TOPICS FOR INVESTIGATION

1. Collect and study the laws of the various states relative to common drinking cups and the installation of drinking fountains.
2. Collect information, pictures, and price lists of drinking fountains suitable for schools where running water is not furnished.
3. Determine the best location for drinking fountains in the school building where you are at work.
4. What diseases are most likely to be contracted by the use of common drinking cups in schools? Collect information from the various state boards of health relative to this question.
5. Do you think individual paper cups will finally prove satisfactory for schools? Why?
6. Collect and summarize the results of careful investigations on the dangers of common drinking vessels.

SELECTED REFERENCES

DAVISON, ALVIN. *Death in School Drinking Cups.* Texas School Journal, September, 1908. pp. 54, 56, 58.

KERR and MOLL. *Common Drinking Cups and Roller Towels.* An analysis of the laws and regulations relating thereto in force in the United States, Public Health Bulletin No. 57. Washington, Government Printing Office, 1912. 30 pp.

MATHENY, W. A. *The Common Drinking Cup.* Pedagogical Seminary, v. 18, pp. 205–213. Bibliography.

ROBARTS, P. T. *A Protest against the Common Drinking Cup.* Iowa State Board of Health Bulletin 24 (April-June, 1911), pp. 101–104.

American School Board Journal. *The Drinking Cup Crusade: a Symposium.* November, 1910. pp. 31–32.

CHAPTER IX

TOILETS FOR SCHOOLS

Location of Toilets. — For buildings not over two stories high the most economical, and on the whole the most isolated and convenient, place for toilets is the basement. Located here, much expense is saved in plumbing, better floors may be made, flushing and washing may be done more safely, good ventilation may be more easily maintained, and privacy is safeguarded. Where sewers are not provided, the plan suggested in the chapter on "Water Supply" can be followed. Disconnected outhouses introduce many difficulties aside from those suggested by inclement weather, lack of space, and neglect.

Good Light for Toilet Rooms. — The rooms in basements where these necessities are placed should be flooded with sunshine during some part of each clear day, and under any condition they must be thoroughly lighted. In placing latrines and urinals care should be taken to avoid obstructing the light, and also to face the stalls so that they will receive as much direct light as possible. To meet these demands most easily for small or medium-sized schools, a long narrow basement room looking toward the south will generally prove most satisfactory. A double row of latrines or urinals placed back to back is almost certain to make lighting unsatisfactory. It is best to put them singly against an inner partition not more than ten or twelve feet distant from the windows. The urinals should be placed near the entrance to the boys' toilets; the latrines are better located farther from the door. This arrangement of urinals and seats will make plumbing more simple, get the outflow into the sewer a little nearer the middle

of the building, and hence make it unnecessary to have a long duct to connect with the ventilating stack. This will operate in giving more rapid ventilation through reduced friction. In order to make this room as light as possible, and at the same time to preserve privacy, the windows may be glazed with ribbed glass and protected from without by a strong coarse-meshed wire screen. In addition to the flushing tank for the latrines and waste pipes for the urinals, a spigot for hose attachment is essential for washing floors and flooding the urinals. If these rooms are well kept and sufficiently large, there is no special reason why lavatories should not be located there also; but if space permits, it is better to place the lavatories in an adjoining room for the sake of decency and to prevent overcrowding.

Floors of Toilet Rooms. — The floors of these rooms should be made of cement, or with a base of strong cement, well tamped and carefully evened to the slope needed. After this base has thoroughly dried, a thin coating of hard asphaltum will render it practically water proof and make the floor less porous, thus preventing the rise of ground air into the room. Asphaltum furnishes an excellent surface at reasonable cost; while tile floors or terrazzo are to be preferred, but are more expensive.

Treatment of the Walls of Toilet Rooms. — The facings of the walls should be of light, glazed bricks, or white tiles, in order to prevent the absorption of light and to make it easy to scrub and disinfect the walls. When walls are so constructed, there is also much less liability of defilement in the way of indecent drawings, or indelicate scribblings, a common indiscretion if not a vice with schoolboys. The ceiling should be constructed with the purpose of preventing, as far as possible, the escape of any possible odors into the rooms above. Perhaps all that can be expected in most school buildings is a good coating of cement plaster finished smooth and when dry painted with a white paint so mixed as to give it a sort of

glazed texture more or less impervious to the air, and which will not be injured by occasional washings.

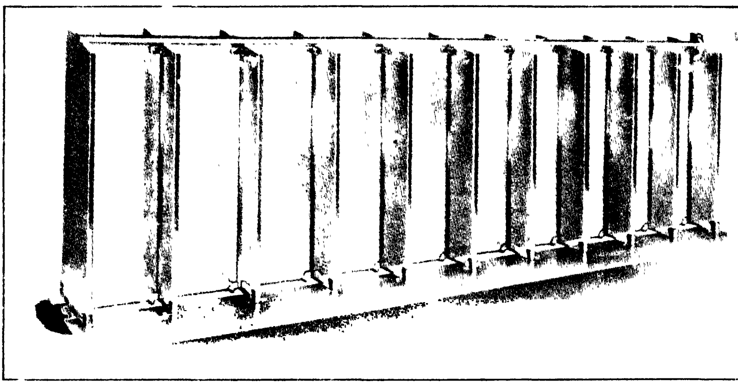
Exposed Plumbing. — It is generally wise to expose the plumbing connected with the water supply in order that inspection and repairs may be made without undue trouble or defacements.

Number of Toilet Seats Needed. — In grammar schools the number of seats that will suffice for the girls' toilet may be determined approximately by dividing one half of the total number of pupils that the building is designed to accommodate by fifteen. That is to say, if the school is built for six hundred pupils, there ought to be twenty seats for the girls. For the boys the number of seats needed may be approximated by dividing by twenty-five. Hence, for the accommodation of three hundred boys twelve seats is generally ample. The number needed, however, will depend to some extent on the distance that the children will have to come. Obviously, if a majority go home during the noon recess, the demands will be lessened. The number of urinals need not be so great, say ten for such a building. There should be enough, but not too many. In this connection it ought to be said that principals can save a good deal of congestion and likewise prevent moral contamination by so arranging the program that dismissals at recess time will be a few minutes earlier for the primary classes than for the upper classes.

In high school buildings, the proportional number of seats may be reduced from the above figures; because study hours and greater freedom in high schools, together with the advanced age of the children, prevent so much congestion in toilet rooms.

Urinals. — Individual urinal bowls are in general very unsatisfactory anywhere, but they are especially objectionable in schools. It is almost impossible to flush them thoroughly, to keep them clean, and to ventilate them properly. They demand more attention than a school keeper can give to them,

and for careless schoolboys are altogether objectionable. Common trough urinals are still worse, and should not be used. The best form of urinal for school purposes, especially for grammar schools seems to be that made by stalls opening at the bottom in a narrow slot through which the flushing water, the urine, and the ventilating drafts enter. The water is caught in a trough below and quickly carried to the sewer connections. The air is carried downward and over these troughs to the exhaust duct connecting with the ventilating stack elsewhere



Wolff's hammered-glass urinal stalls (ventilated).

described (see the illustration, p. 122), or with an exhaust outlet operated by a special fan.

The choice of material for the sides and backs of the urinal stalls will, of course, depend partly on the money available. A good quality of slate, hard seamless marble, or, better, white glass slabs is to be recommended. Glass has the decided advantage of being nonabsorbent and of being readily cleaned. The outer edges of the glass slabs should rest in a framework of noncorroding metal, to prevent breakage. Naturally, the back of the stall should incline forward toward the bottom and receive the cleansing spray evenly distributed across the top.

Toilets on the Main Floor. — In two-story buildings there should be on each floor above the basement one seat for the girls and one for the boys. These should be used only for emergencies. On each of these floors, also, the teachers should be accommodated with both lavatories and toilet necessaries, one for each sex. It would seem almost needless to state that these must be well lighted and have good ventilation.

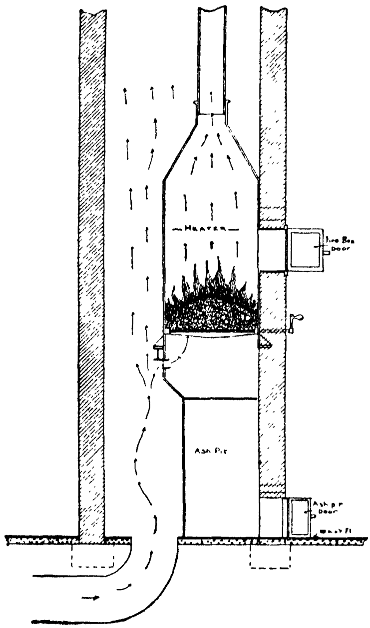


FIG. 26. Form of heater for ventilating toilets and urinals. (Courtesy of U. S. Bureau of Education.)

Ventilation of Toilets and Urinals. — All toilets and urinals should be ventilated directly down and through them, so that no odors can escape into the toilet room. This ventilation system ought to be wholly independent of any other in the building. Otherwise reverse currents may give trouble.

Probably the safest and simplest method of ventilating the seats and urinals consists in building a separate stack, at as near-by convenient place as practicable, with a stove or grate built into it from the basement in such a way that after the fire is built, all of the draft needed for combustion, and that caused by the outflowing heated air, will be drawn through an underground duct connected with the seats and urinal outflows near the sewer connections. This stack may be built in a main chimney, but is not to have any direct communication with any other draft. Sometimes in small buildings

the escaping heat from the fires may be made to warm this stack so as to aid the outflow of air. Where steam heat is used, steampipes placed in it, instead of the stove or grate, will serve the same purpose. But even during the winter season, when hot fires are needed to warm the rooms, it is safer to supply this ventilating stack with an independent means of heating, so that during the night, and especially during week ends and holidays, this fire may be kept going without the extra expense incurred in keeping a boiler or furnace hot. This fire must be kept burning winter and summer during the school session. To this end, it is especially desirable to make due provision for a fire that will last. Hence a large fire box arranged to insure a slow, steady heat without frequent replenishings will save trouble and fuel and insure safer ventilation. When these provisions are made, and *fire is kept burning*, basement toilets and urinals can be kept pure and altogether unobjectionable.

Automatic Washout Bowls for Schools Needed. — The seats should have an automatic washout attachment, for school children cannot be depended on to regulate the flushing. Where a number of seats are connected with the same discharge trough, there must be an occasional discharge of water great enough to sweep it clean. There are numerous patent devices made to accomplish this purpose, and in general it may be said the simplest is the best. The problem of supplying each separate seat with a flushing tank to be operated automatically when the seat is used, or of furnishing a release to be operated by the pupil himself, is not altogether satisfactory for primary classes. Generally, as indicated above, it is better not to depend on children entirely to regulate matters of this sort, but if possible to utilize both methods. It is plain that unless the general flushing tank is operated very rapidly, some provision ought to be made to wash out each individual seat as soon as used; otherwise even with good downward ventilation there is some danger of escaping odors. However,

if the receiving trough is placed well below the seats and a strong downward draft maintained, there is usually no trouble, especially if the flushing tank is speeded up during periods of intermission. Where the water supply comes at small cost, and where sewer connections are ample, there can be little complaint when dependence is placed solely on a general automatic flush, for it can be set to discharge at a rate to meet demands. The troubles of plumbing arising from a great number of individual tanks are so annoying and expensive that such tanks are likely to be frequently left in bad repair.

In some of the newer schools in Germany, the regulation of the flushings is accomplished by means of a clock which can be set so as to effect rapid flushings at periods corresponding to those for intermissions. These clocks are similar in arrangement to ordinary program clocks, but of course much less complicated. Any mechanic can make such connections with an ordinary clock.

Sanitary Toilets for Country Schools. – In country schools where outhouses are necessary, they can be made less conspicuous by covering them with vines, shielding them by a clump of shrubs, or by a latticework fence. The urinals connected with such outbuildings should be in the open air and completely hidden from the playground. One of the best means of keeping dry closets free from odor is to have at hand a good supply of dust gathered from the roads in dry weather, or fine ashes to scatter over the excreta. For this purpose a bin can be built in each of the outhouses, from which the material can be scooped as needed. It is good civics to teach the children how to use these means of cleanliness, and to give them the reasons for using dust, ashes, or slaked lime. Instead of deep pits or cesspools, it is far safer in wet soil to have buckets underneath the seats which can be drawn out and emptied as often as needed. It is almost impossible to keep a pit clean and free from odor, even though it is not water-soaked.

The outhouse, when we have to put up with such inconveniences, demands far more attention than it usually gets; but soon it ought to be possible to install in every country school a system of septic tanks connected with washout toilets. An ordinary force pump to be worked by hand with a supply tank high enough to drive the water through the feed pipes to washout toilets can be installed at almost any school, and will be when people are sufficiently informed of the dangers of open vaults. Such conveniences would have a good reflex influence in the homes represented. There are many country schools so located with reference to a water supply that with a little planning on the part of the teacher or county superintendent, water can be carried from springs or running streams to a sunken tank on higher ground and from there distributed for use in the toilets, the garden, and, if pure, to the schoolroom for drinking purposes. What we need to make our country schools more wholesome and attractive is not so much more money as it is more intelligent and vigorous supervision. There are many opportunities not utilized simply for lack of suggestion and definite guidance. A good sanitary, decent, toilet system at a country school will in time set better standards in this respect for the homes.

Dangers of Insanitary Toilets in the Country. — Those who are conducting the crusade to exterminate hookworm disease, and to protect against typhoid fever, have come to see that no permanent relief from the spread of these diseases can be secured until sanitary toilets are used. Hookworm disease is caused by parasitic worms which fasten themselves to the inner walls of the intestinal tract by small hooks. Those afflicted with this disease discharge the eggs in the excreta. After these have passed through the required stages of development, if brought into contact with the skin of the hands or feet, they burrow through until they reach a blood vessel and finally lodge in the intestinal tract. It is obvious that the eggs of this parasite must not be allowed

to develop or to infect the soil about the home or school. The only way to prevent this infection is by the installation and use of toilets designed to destroy them. In cities and towns where adequate sewer systems are found, washout toilets are sufficient. But in villages and in the country other methods must be devised.

Typhoid Fever and Insanitary Toilets. —Typhoid fever is a germ disease, and myriads of these germs are discharged in the urine and feces of those afflicted. Hence all the precautions taken for protection against the hookworm are necessary to combat typhoid germs. It has been discovered, in recent years, that the common house fly carries these germs on his feet and body, if he is allowed to come into contact with excreta containing them. A toilet, then, must be so constructed that flies cannot enter the vault or in any way come into contact with this germ-laden material.

Forms of Sanitary Toilets for the Country. — The most promising form of sanitary toilet for homes and schools, where flowing water and washout toilets are not yet available, appears to be that developed by Lumsden, Roberts, and Stiles, known as the L. R. S. Privy and described by Dr. Ferrel of the North Carolina Board of Health as follows: —

"The apparatus under consideration consists of the following parts:

"1. A water-tight barrel to be used as a liquefier.

"2. A covered water-tight barrel, can, or other container to receive the effluent.

"3. A connecting pipe about two and one half inches in diameter, about twelve inches long, and provided with an open T at one end, both openings of the T being covered by wire screens.

"4. A close box, preferably zinc-lined, which fits tightly on the top of the liquefying barrel. The box is provided with an opening on top for the seat, which has an automatically closing lid.

"5. An antisplashing device consisting of a small board placed horizontally under the seat one inch below the level of the transverse connecting pipe; it is held in place by a rod, which passes through eyes or rings fastened to the box, and by which the board is raised or lowered. The

liquefying tank is filled with water up to the point where it begins to trickle into the effluent tank.[1]

"As an insect repellent a thin film of some form of petroleum may be poured over the surface of the liquid in each barrel.

"Although some of the fecal matter floats, it is protected both from fly breeding and fly feeding in the following ways: first, by the auto-

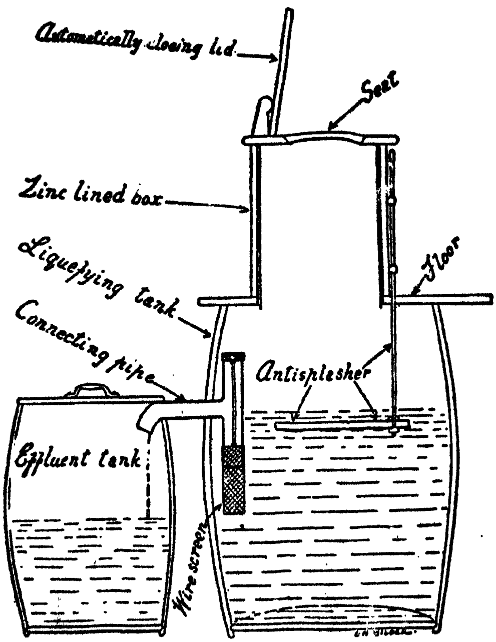


FIG. 27.—The L. R. S. sanitary privy tanks made of barrels. (Courtesy North Carolina State Board of Health.)

matically closing lid; second, by the water; third, by the film of oil; and fourth, for additional safety, the apparatus should be located in a screened place. The film of oil also prevents the breeding of mosquitoes in the barrel. Accordingly, so far as the privy as a breeding or feeding place for flies and mosquitoes is concerned, the model in question completely solves the problem.

[1] This antisplasher can be eliminated without lessening the value of the toilet.

"The fecal material becomes fermented in the water and gradually liquefies; the addition of excreta naturally raises the level of the liquid, and the excess flows into the effluent tank, where it is protected from insects by the cover and by the film of oil. This effluent may be allowed to collect in the tank until it reaches the level of the connecting pipe, when it may be safely disposed of in various ways to be discussed later.

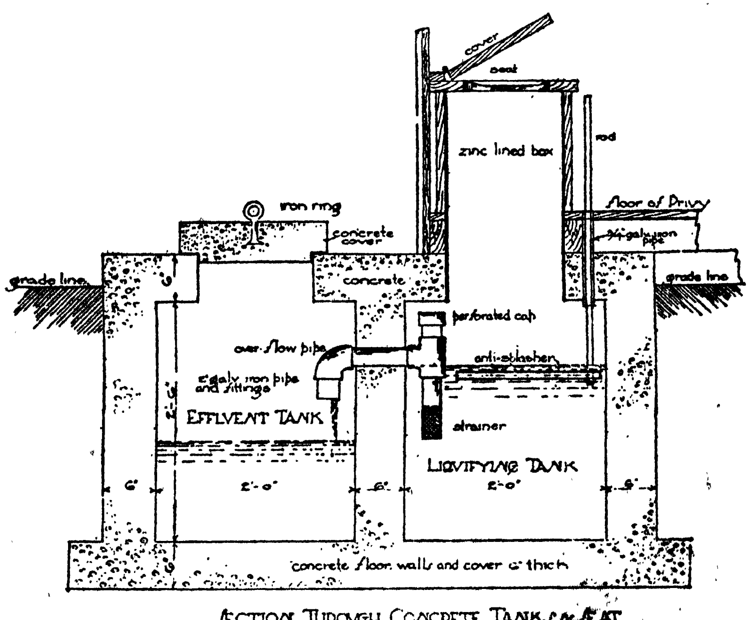


FIG. 28.—Concrete tanks as a means of permanency in using the L. R. S. toilet. (Courtesy North Carolina State Board of Health.)

"This form of privy seems to meet the following requirements:—

"1. It solves the fly and mosquito problems, so far as the privy is concerned.

"2. It liquefies fecal matter and reduces its volume so that it may be safely disposed of more easily and cheaply than night soil.

"3. It reduces odor.

"4. It reduces the labor of cleaning the privy and makes this work less disagreeable.

"5. It is of simple and inexpensive construction.

"The effect of the fermentative changes in the apparatus upon the viability of typhoid bacilli and hookworm eggs has not been determined, but other experiments tend to show that under such conditions the vast majority of typhoid bacilli and of hookworm eggs introduced would die within six weeks' to two months' time. While the time of storage can be prolonged according to the capacity of vessels provided for the purpose, we believe at present that it is safer and more practical not to depend upon storage alone to destroy infectious organisms in the effluent, but to consider the effluent infectious and to dispose of it accordingly."

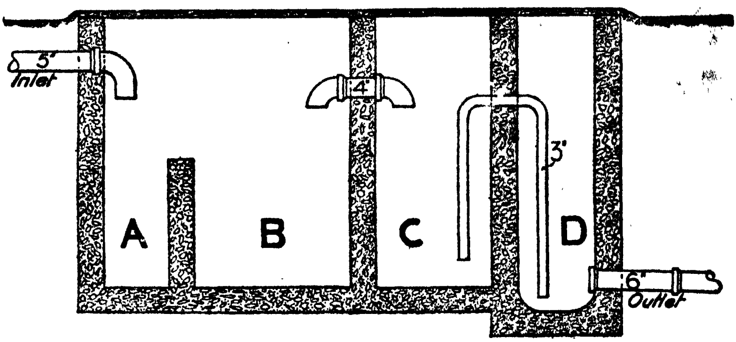


FIG. 29. — A simple septic tank for a country school. *A*, settling chamber; *B*, septic tank proper; *C*, so-called "dosing tank," from which the absorption field is dosed at intervals by means of the siphon; *D*, siphon chamber. (Courtesy U. S. Bureau of Education.)

Septic Tank Disposal. — A septic tank disposal system may be described briefly in the following way. At some distance from the building and on lower ground there are built two or more underground tanks and connected as in Fig. 29. These are connected with the source of the sewage by means of sewer pipes carefully cemented together to prevent leakage. From the last tank a drain leads to lower ground, and is here connected with a series of radiating drains of earthen tiles, which permit the liquid thus delivered to them to escape into the surrounding soil where it is soon rendered inert by the action of the bacteria in the soil. The siphon arrangement shown between *C* and *D* regulates the flow so that the outgoing drain is intermittently supplied with the accumulated liquid

waste. This gives the soil time to purify itself and thus prevent odors, or surface contamination. Naturally, if the ground is gravelly or sandy, the capacity of these tanks and drains to dispose of the sewage is much increased. Also, if they are situated in considerably lower ground than that upon which the building is placed, they are more effective. These tanks may be made by building in appropriate excavations cement receptacles or brick receptacles thoroughly cemented inside and out so as to make them water-tight. They need not be more than four or five feet deep, though the depth should be regulated to suit the level of the ground into which the liquid is to be carried. These will last for a long time, and will, when properly constructed, prove fairly satisfactory for small schools. It is perhaps worth while to call attention to the fact that care must be taken to guard these tanks and their connections from clogging with coarse paper or waste from laboratories.

With such a system as here briefly outlined, a country school can become as sanitary, as convenient, and as wholesome as the most favored city building.

As the result of a recent investigation into the sanitary condition of thirteen hundred rural schools, in nineteen states, it has been found that less than five per cent have sanitary toilets. Moreover, more than one half of them have to depend on neighborhood wells and springs for drinking water. It should not require arguments or further plain talk to make it clear to any one who has enough common sense to serve on a school board or to supervise the construction of necessary conveniences at schools, the urgent necessity for immediate relief from the vile outhouses so often found in connection with country schools. It will not suffice to teach people how to rid themselves of disease, they must also be taught how to guard themselves against attack. Every county superintendent, every teacher who is worthy the name, and every school board measuring up to the responsibility accepted, must know

these facts, and must work to eradicate or at least to check these evils.

TOPICS FOR INVESTIGATION

1. Make a careful study of some of the epidemics of typhoid fever that have been traced to contaminated water supply.

2. Gather as much information as you can about the construction of sanitary toilets for the school and the home. Utilize this, in due time, in your efforts for better public sanitation.

3. Make a drawing of a septic tank disposal system for a home, that provides for the disposal of the waste through tile drains laid below the surface of the ground. (See various books on rural hygiene and sanitation.)

4. Make a study of the requirements necessary for the proper location of a schoolhouse or a home, in order to take advantage of the septic tank disposal system.

5. Devise some method or plan for getting the people of a neighborhood to make a concerted effort to construct sanitary toilets at schools and at their homes. State boards of health, as well as local health boards, will gladly help in such undertakings.

SELECTED REFERENCES

BASHORE, H. B. *The Sanitation of a Country House.* New York, 1905. 103 pp., illus.

EGBERT, S. *Hygiene and Sanitation.* Philadelphia, 1910. (See especially Chap. 12.) 508 pp., illus.

GERHARD, W. P. *Sanitation, Water Supply and Sewage Disposal of Country Houses.* New York, 1909. 328 pp., illus.

New Hampshire State Board of Health. *Sanitary Bulletin.* Concord, N.H., January, 1911, v. 3, No. 12, illus.

North Carolina State Board of Health. *The North Carolina Standard Sanitary Privy.* Raleigh. 15 pp., illus.

STILES, C. W. *The Sanitary Privy: Its Purpose and Construction.* Public Health Bulletin No. 37. Washington, Government Printing Office, 1910. 24 pp., figs.

CHAPTER X

THE NEED OF PURE AIR

Life and Oxygen. — There can be no life without oxygen, and animals get their supply of it from the air. Air is a mixture of several gases, chief among which are nitrogen, oxygen, and carbon dioxide. All animals breathe: some through lungs, as man, others through gills, as fishes, and some through tube-like openings in their bodies, as grasshoppers. The higher animals breathe mainly through their lungs, though the skin in most of them has some power of transpiration. Cut off from a supply of oxygen, man quickly dies, because the vital processes cannot proceed unless the tissues are constantly bathed in this essential element. We must not think, therefore, that the oxygen in the air goes no farther than the lungs, for these are only the sources from which the blood gathers its supply, and from them carries it to every fiber and tissue of the body. Each action of the body, whether voluntary or involuntary, requires oxygen, and hence each tissue must be supplied if it is to live and to carry on its functions. Fifteen to sixteen times every minute, as you do the ordinary work of the day, the lungs are expanded through the pressure of the air, when the diaphragm is pulled down and the ribs elevated by the muscles for these purposes. Equally often, of course, as these muscles relax and thereby reduce the capacity of the chest, the air is driven out of the lungs. This process has not stopped since the first breath, and will not until death. It must go on during sleep as well as during waking hours, for the body is ever hungry for oxygen. One can consciously increase or decrease this rate for a short time, but fortunately it goes on in the main unconsciously. Death would ensue immedi-

ately if all the oxygen were removed from the body and breathing ceased.

Increased Activity increases the Demand for Oxygen. — Walk rapidly up a hill, or run a hundred yards, then observe the rate and depth of your breathing, and ask yourself this question, "What has caused this hurried *demand for more* fresh air?" Naturally, you will say, the *increased activity* or strain has been the cause. But suppose we examine a little more closely to see as nearly as we can what really has happened in the body, for then we can understand better the need of fresh air. The fibers of the muscles, as well as the nerve cells and all other tissues of the body, are supplied with more or less minute blood vessels for the purpose of furnishing to these tissues sustenance and oxygen, and for carrying off waste materials. When the tissues increase their usual activity, they will need more sustenance and more oxygen. The heart will begin to beat faster and with more force, in order to furnish these supplies, and the breathing will increase in rate and volume, in order to furnish more oxygen to the blood and to release the increased volume of carbon dioxide. Every action of the body, consciously or unconsciously performed, therefore, uses up the material of the tissues involved in the action and also the supply of oxygen immediately at its command.

How the Oxygen gets to the Tissues. — When one undertakes to know completely what happens during breathing, he will at once see that introducing air into the lungs is really just the beginning of the process of supplying the body with oxygen. He will wonder first how the oxygen gets into the blood, and how the blood can take up and carry a gas all through the various parts of the organism. He knows that blood must be carried in the blood vessels and that the air as breathed cannot mix directly with the blood in the lungs; otherwise the blood would soon fill the air cells and would finally be expelled by coughing, as in hemorrhages. Hence

there must be some way to keep the blood out of the lungs, and at the same time there must be some method for the oxygen to get in and the carbon dioxide to get out.

The Principle of Diffusion of Gases. — A gas can pass through a thin membrane which will not permit the passage of blood, just as water can pass through a thin cloth, while a thicker substance would be held back. Thus the oxygen in the lungs, separated from the blood by the thin membranous walls of the blood vessels ramifying in all parts of the lungs, can get into the blood, and the carbon dioxide which has been formed in the body through the breaking up of the tissues by the life activities can get from the blood into the lungs. But, you ask, what makes the oxygen enter the blood and the carbon dioxide leave it? Possibly no one can answer this question completely, but it is a fact that gases, when separated as they are here by membranes through which they can pass, tend to establish an equilibrium. That is to say, if the percentage of oxygen in the lungs is greater than that in the blood, and *vice versa*, the percentage of carbon dioxide is greater in the blood than in the lungs, then each gas will flow toward the point of less supply in order to establish equilibrium. The force thus exhibited is called diffusion of gases, and tends to keep the gases of the atmosphere evenly distributed. Were it not for this diffusion of gases, life would be endangered as we move from place to place. It used to be said that because carbon dioxide is heavier than the other constituents of the air, we would always find it near the floor of our schoolrooms in much greater abundance than at higher points in the room. This is not often true, and could never be true except in an extreme state of overcrowding and lack of ventilation in the room.

Thus we see that the blood is constantly calling for oxygen, and the air in the lungs is constantly drawing off, as it were, the burden of carbon dioxide that the blood accumulates from the tissues in its circulation.

The Red Corpuscles of the Blood as Oxygen Carriers. — Moreover, the oxygen not only passes into the blood from the lungs, but it is attracted to certain elements of the blood. The red corpuscles, or cells of the blood, contain a material known as hæmoglobin, which has the power to absorb the oxygen entering the blood from the lungs. When these corpuscles are replete with oxygen, they take a bright red color. Arterial blood is therefore not as dark as venous blood, for the former is on its way from the lungs to the tissues, where it will distribute its oxygen, and the latter is on its way from the tissues to the lungs. When we speak of good red blood, we mean blood that is well supplied with both nourishment and oxygen. If the blood for any reason has a diminished supply of hæmoglobin, the tissues cannot receive their needed amount of oxygen, for the blood lacks power to carry and distribute it, and the system suffers as a result.

One of the most significant tests that physicians now apply to determine undernourishment and anæmia is that of noting the condition of the blood in this regard.

The Plasma of the Blood as a Carrier of Carbon Dioxide. — The watery substance of the blood in which the various corpuscles are floated and carried has power to absorb and carry the carbon dioxide from the tissues to the lungs, and there to give it up as already explained. Hence, to rid the system of the accumulating supply of this gas produced by the activity of the tissues, the blood needs to have abundant supply of water, which is absorbed into it through the length of the digestive tract. The lymph surrounding the tissues also absorbs carbon dioxide, and carries it toward the lungs through the agency of the lymphatic circulation. There are many other features connected with the process of supplying oxygen and the removal of carbon dioxide, but these may be learned from the larger textbooks on physiology. It is enough, for our present purpose, to understand that the body is in constant need of a renewed supply of oxygen, an equally effective

means of discharging carbon dioxide, and that when these conditions are not furnished in our schoolrooms, the life processes are disturbed and more or less seriously interrupted.

How Much Fresh Air is needed for Each Child per Hour? — It is obvious from what has been said above that the amount of oxygen that a pupil will need will depend on his activity, and that his activity will be conditioned in turn by the amount that he receives. A pupil engaged in vigorous physical exercise, such as playing ball or going through gymnastic drill, always needs more fresh air than he would if he were doing the ordinary quiet work of the schoolroom. Hence, it is always better, when weather permits and other conditions are equal, to have outdoor games rather than indoor gymnastics. It has been determined, with a reasonable degree of accuracy, that children in the primary classes need at least two thousand cubic feet of fresh air each hour, those in the upper grades two thousand five hundred cubic feet, and those in the high school three thousand cubic feet. Of course, pupils will not perish if they get less than these estimates, but they will not be able to do their work easily and effectively, without fatigue and lassitude, unless they are furnished with approximately these amounts. In making such estimates it would be poor hygiene to stint them, or to suggest that they be cut off with less than their systems demand. These figures do not represent the amount of air that they breathe, but the amount that they vitiate each hour. An expired breath contains approximately one hundred times as much carbon dioxide as the same volume of normally pure air. That is to say, in pure air there are about four parts of carbon dioxide in each ten thousand parts of air, but an expired breath contains four hundred parts in ten thousand. Hence, each breath will throw into the air enough to raise a hundred times as much air to a percentage of eight parts of carbon dioxide to ten thousand parts. It is generally conceded that the air of a schoolroom should never be allowed to show more than

ten parts of this gas in ten thousand parts. Besides, it is certainly a foolish procedure to attempt to give the children the minimum air permissible, instead of the maximum. It is better to err on the side of plenty.

Standard of Air Purity. — In the light of some recent experiments, it seems probable that too much emphasis has been placed on the deleterious effects of carbon dioxide alone. But where carbon dioxide is abundant the amount of oxygen is correspondingly decreased, and the escape of carbon dioxide from the blood to the air in the lungs is impeded. The amount of carbon dioxide in the air of a schoolroom is an index both to the relative amount of oxygen and to such organic impurities as may be thrown off from the body. The circulation of the air is also a significant element in schoolroom ventilation. It is plain, however, that nature has gone to great pains to adjust the human mechanism to the conditions of the atmosphere as we find it out of doors; and here we find slightly less than twenty-one per cent by volume of oxygen, seventy-nine and one half per cent nitrogen and argon, and approximately four hundredths per cent carbon dioxide. Manifestly it is a justifiable conclusion to say that this proportion should be the one that we should seek to maintain in all of our schools, homes, and public assemblies. This is nature's standard of purity to which we have been adjusted biologically, and no conclusion running contrary to this can be a safe guide for healthful conditions in our schools.

New Theories on Ventilation. — Recently there has been much talk over experiments made by Hill, Benedict, and others as to the effect or noneffect of breathing impure air. The experiments made by these men seem to show that the chief, if not the only, ill effects resulting from breathing the air of a crowded and badly ventilated room come from a high temperature with an undue amount of moisture mixed with the air. They say, in brief, that if a room has a good circulation of the air, and the temperature and the humidity are kept

at the proper physiological standard, the air may be breathed until it is very foul without experiencing any bad effects.

There can be no doubt that circulation of the air within a crowded room will prevent much of that feeling of drowsiness and dullness that one is accustomed to feel in quiet, overheated, and moist air. The body must lose some of its heat by evaporation, or by other means, else normal physiological conditions cannot prevail. If, as has been said elsewhere, the temperature of the air is high, and the relative humidity also high, the heat normally produced in the body will accumulate. If the air be thirty degrees colder than the normal temperature of the body, the humidity at fifty per cent saturation, and the blanket of air about the body is being changed constantly, the perspiration will be readily evaporated from the skin and in this way the heat produced through the normal bodily activity will not accumulate and the body will thus be kept at the proper temperature. But it would certainly be unscientific to say that the experiments thus far made have "revolutionized all preëxisting theories of ventilation."

There is no getting around the fact that normal outside air is a mixture of various gases, and that the relative percentage of the components of this mixture is very nearly constant. The human organism developed in the open air, and its physiological processes were adjusted, through countless ages, to conditions there prevailing. Of course no one knows what the relative percentage of the various elements of the air was during all these ages; but it is safe to say that man today *is* adjusted to normal pure air such as we find in the open country, and that unless he is furnished with an atmosphere of approximately the same constituency as that now prevailing in the open country, he will suffer as a consequence. Hence to attempt to browbeat nature's demands by limiting his supply of oxygen, and by bartering an excess of carbon dioxide for a "breeze," must at last prove to be deleterious, if not dangerous. A "breeze" is good and of great

value under given conditions of the air; but nothing can take the place of oxygen, and nothing will atone for the use of an atmosphere with an abnormal excess of carbon dioxide, and the questionable companions which usually accompany it. The only safe standard of air to which all methods of ventilation should be adjusted is *pure air*. The methods employed for heating, conditioning, and moving of this air, so as to meet the other needs of the body are important, but they cannot be used as substitutes for purity.

TOPICS FOR INVESTIGATION

1. Make a careful study of the results of tests made on city air and country air, and determine what causes are operating to account for the differences.

2. Make an investigation into the habits of city and country people regarding the ventilation of bedrooms.

3. Take a tin box, put into it some damp moss and a live toad, cover and solder the box air-tight, and put it in a cool place for a week; then open and note the condition of the toad. Explain the results noted.

4. Explain fully why you breathe at a more rapid rate during vigorous exercise than when at rest.

5. Gather together as many estimates as you can find relative to the amount of fresh air needed per hour by children in the primary grades, elementary grades, and high school. Especially study the reasons given for the amounts demanded.

6. Why is the test for hæmoglobin in the blood a significant test from the hygienic point of view?

7. Make a careful study of the entire process of supplying the tissues with oxygen, and of eliminating carbon dioxide and other deleterious gases formed in the body through oxidation.

SELECTED REFERENCES

Billings, Mitchel, and Bergey. *The Composition of Expired Air, and Its Effect on Animal Life*. Smithsonian Report, 1895. pp. 389–412.

Cohen, J. B. *The Air of Towns*. Smithsonian Report, 1895. pp. 349–387.

EDWARDS, GLEN. *Carbon Dioxide and Ventilation.* Amer. School Board Journal, October, 1911, v. 43, pp. 19, 31.
INABA, R. *Über das Kenotoxin Weichardts in der Ausatmungsluft.* Zeitsch. f. Hyg. u. Infection-Krankheit, v. 68, pp. 1–26.
MACFIE, R. C. *Air and Health.* London, 1909. 345 pp.
PETTENKOFER, MAX VON. *The Relation of the Air to the Clothes we wear, the Houses we live in, and the Soil we dwell on.* London, 1873. 94 pp., illus.
RICHARDS, E., and WOODMAN, A. G. *Air, Water, and Food.* New York, 1911. 278 pp., illus.
ROSENAU, M. J., and AMOSS, H. L. *Organic Matter in Expired Breath.* Jour. Med. Research, v. 25 (1911), No. 1, pp. 35–84.
RUSSELL, F. A. R. *The Atmosphere in Its Relation to Human Life and Health.* Smithsonian Misc. Collections, v. 39, 148 pp.
WOODBRIDGE, S. H. *Pure Air as an Investment.* Boston, 1909. 23 pp.
VARIGNY, H. C. DE. *The Air and Life.* Smithsonian Report, 1893. pp. 125–201.

CHAPTER XI

VENTILATION

Some Elementary Principles of Ventilation. — The first thing to learn touching practical schoolroom ventilation is that the attention given to ventilation in the home and the methods used there are entirely inadequate and insufficient when applied to the problems of schoolroom ventilation. The habit acquired in the home with respect to ventilation makes it more difficult for teachers to adjust themselves to the needs of the schoolroom than would be supposed. This statement is made because much observation of what actually takes place in the way of schoolroom ventilation and much practical experience in the direction of teachers have led me to feel that in order to get results, emphasis is needed here first. In the home, even with a large family gathered in one room, there is far less overcrowding than we find in the average schoolroom. There is a greater number of cubic feet of air space for each member of a family of twelve (a very unusual family these days) when gathered in a room sixteen feet square and ten feet from floor to ceiling than there is for each of forty-five pupils seated in a schoolroom thirty-two feet long, twenty-four feet wide, and twelve and one half feet from floor to ceiling. In addition it must be remembered that, in the home, doors are often opened, the members of the household are going and coming, the rooms are often provided with open fires, and all together the opportunities for fair ventilation without much attention being given thereto are much greater at home than they are in the schoolroom. At school the children are kept quiet, the doors are seldom opened save during intermissions, and in every way there are fewer unplanned oppor-

tunities offered for the introduction of fresh air than are afforded in the home. So it is necessary for teachers to develop a new consciousness, as it were, in regard to carefulness in the matter of ventilation. In order to understand this phase of hygiene, it is well to consider somewhat carefully the physical principles upon which so-called natural ventilation depends.

Changes in Temperature cause Movements of the Air. — In the first place, all movements of the air not produced by mechanical means and the rotation of the earth are due to changes in weight caused by changes in temperature. When air is heated, it expands and so, bulk for bulk, is lighter than cold air; hence warm air tends to rise, while the colder and therefore heavier air sinks. If the air outside a building is colder than the air inside, when the windows are opened, a movement will be started at once to establish equilibrium. For the moment, if we neglect the influence of the wind, it will be easy to see how the currents of air thus produced will move. If the windows are opened from above, cold air will come in at the lower part of the opening thus made and settle more or less slowly and obliquely toward the floor. The greater the difference between the temperature of the incoming air and the air already in the room, the more rapid will be the movement of the currents of air, and the more directly downward will be the path of the incoming current. But it must be understood that in practice these statements will not always prove true. For, owing to the mixing of the cold air with the warm, and the crowding of the warm air toward these openings, the movements will be irregular and at times wholly in one direction. If some partitions be inserted so as to divide these openings, made by lowering the windows, into two nearly equal divisions, the cold air will then come in with less difficulty at the lower one and the warm air leave through the upper with greater regularity. When this incoming air is only slightly colder, it moves slowly and obliquely toward

the floor, and by reason of this becomes warmer because of its contact with the warmer air in the room. It may happen then that the pupils seated next to the windows are receiving sufficient fresh air, while on the opposite side and away from windows and in corners there may be an insufficient supply. The tendency, however, is for the colder air to settle gradually toward the floor and, as it becomes heated, to give place in turn to the colder. For example, if the temperature of the air within the schoolroom is seventy degrees Fahrenheit and the air without fifty degrees Fahrenheit, when the windows are opened at the bottom and the top, this heavier air will move in at the rate of about five feet per second. But plainly if the difference in temperature be only half so great, the rate of the air currents will be reduced by one half. It follows, then, if ventilation of schoolrooms is to be effected by opening the windows, larger openings must be made when the air without and that within is near the same temperature, than when greater differences exist. During the winter, in cold climates, small openings suffice for the entrance of much fresh air. Larger opportunity for change must be given in warm weather. Neglecting for the moment the variable significance of the wind as an aid or hindrance to adequate ventilation, the reader can readily see that a system of ventilation or a set of rules devised to secure proper ventilation for some parts of our country would prove unsatisfactory and inefficient for other parts. The school authorities of those states which have equable climates, where the air outside is for the greater part of the year and especially the school day about the same temperature as that needed within the schoolrooms, have to make greater provisions to secure fresh air than do those who manage schools situated in states with colder climates.

Difficulties of Ventilation in Warm Climates. — For example, the school authorities of California have a very difficult climate with which to contend with respect to matters of school-

room ventilation. For, in most parts of the state and for the greater part of the year, the outside air during the middle of the day differs but a few degrees from what it should be when reaching its greatest temperature within. Hence, when fresh air is most needed it is least likely to come in of its own accord, if one be allowed to express it so. What is true in this regard of California is also true to a greater or less degree of several other western, southern, and southwestern states. The rate of the incoming air can be easily measured and varies, as we have said, according to the difference in the temperature between it and the air within. While the air outside in these states is in the main unusually pure and wholesome, its proper introduction into the schoolroom and public buildings in general is not an easy matter. In the first place, rapid changes in temperature of the external air take place during the morning hours, so that frequent changes must be made in the positions of the windows to maintain regularity in the supply of fresh air. In the early morning hours, it may be that if the windows are all lowered eight to twelve inches, it will suffice; but at noontime such an arrangement would be entirely inadequate, for at this time and during the rest of the school day the temperature outside is nearly what it should be inside, and much less air would enter the schoolroom through the same opening than in the morning. It would not do, therefore, to set the windows for the day and expect proper ventilation. For in so doing we would either keep the room too cold in the morning, or fail to supply sufficient pure air in warmer parts of the day.

It is necessary to introduce a steady and continuous supply of pure air and circulate it in order to make sure that the requisite amount of oxygen is maintained. It is therefore unsafe to attempt to provide pure air for schoolrooms in this natural way when the movement is necessarily irregular. But it is not an uncommon experience to see teachers wholly neglect this principle and undertake to satisfy hygienic de-

mands by an occasional change of air or by setting the windows to suit the temperature of the morning hours and leaving them so for the whole day. Busy teachers are not only forgetful, but they are unconscious of the increasing impurity of the air until harm has been done.

To illustrate the importance of a knowledge of the principle here insisted on, permit me to refer to a bit of recent experience. A committee of intelligent and public-spirited women was appointed by the federated clubs of a certain city to look into the hygienic conditions of the schools. They visited a modern building of twenty rooms and among many other appliances new to them found that, instead of keeping the windows open for the introduction of fresh air, the air was being forced into the rooms by means of fans driven by an electric motor. Seeing the windows all closed, it appeared to them that the air must be very impure, despite the fact that it seemed good. Being called in consultation, I was told that it seemed very bad to them to deprive the children of fresh air by keeping all the windows closed, for it was a warm, bright summer day and no fire was needed. "Suppose," I replied, "you stop the fans and open the windows, what is going to make the air come in, and especially rush in fast enough to meet the needs of fifty children?" The reply was, "Why, the air will just *come* in." It was only after a long explanation and many questionings back and forth that they appeared to understand that air was not alive and did not move in any direction without some adequate cause. Open windows had satisfied home demands, and they did not understand why it would not meet the same requirements in schoolrooms, especially on a warm, quiet, sunny day. And it must be acknowledged that school principals and superintendents are sometimes guilty of almost as much carelessness in their reasoning touching matters of schoolroom ventilation as were these women.

Many principals whose buildings are equipped with fans for supplying sufficient fresh air, in order to cut down the expenses incident to driving the fans, direct their janitors to stop the fans in the afternoons when the air is warm outside and depend upon windows for ventilation. They do not seem to see that this is just the time and these are just the conditions when the fans are most needed. Warm, sunny, quiet days are just the days when children who are confined in

schoolrooms suffer most when their teachers are compelled to depend on ordinary windows for ventilation. This is a plain simple doctrine, but ignorance of it is widespread even among teachers.

Diffusion of Gases. — Again it will be well to note in this connection that the expired air leaves the nostrils at about the temperature of the body, and when the surrounding air is at the proper temperature, sixty-five to seventy degrees, it rapidly rises. Considering these facts alone, then, it would seem that, in order to have a sufficient amount of pure air, we would have only to note the air currents and to regulate them accordingly. But another principle is involved in such a way as to complicate things very much, and to render the process of securing pure air much less easy than it would otherwise appear. This complication is due to a principle already explained. When gases come into contact, even though one be lighter than the other, there is a strong tendency for them to mix. So, notwithstanding the fact that expired air may be lighter than the air into which it is breathed, its noxious gases will tend to spread themselves throughout the air in the whole room. It is a mistaken notion, and one that is responsible for much erroneous practice, to suppose that all the gases and odors given off with the breath immediately thereafter seek the ceiling or floor and remain there until allowed to escape.

On the other hand, it is sometimes argued, because carbon dioxide is heavier than normally pure air, that it will collect near the floor, and that, accordingly, some special openings are needed here to get rid of it. If a quantity of pure carbon dioxide were poured out of a vessel into the air of a room, it would, without doubt, settle to the floor, and for a time remain decidedly more plentiful there than at any other point, but in time it would become diffused through the air. When, however, we consider the problem from the point of view of contamination through respiration, we see that, owing to the comparatively small amount of it thrown into the air with

each expired breath, there is ample time for its general diffusion throughout the room.

Ventilation through Windows. — At the present time most country schools and even many village schools are equipped with no other means of ventilation than windows, and it is worth while to consider briefly what is best to do under such conditions.

In warm or mild weather with windows on but one side of the room, it is better to lower *all* of the windows a sufficient distance to warrant an adequate influx of fresh air, than to lower one or two a much greater distance. It seems almost trivial to state such an obvious principle, but many teachers act as though they were utterly ignorant of it. It certainly is within the power of all teachers to see to it, when they are so situated that they must depend on windows for ventilation, that all of the windows are lowered; but it is a rare thing indeed to find this carried out in practice. If the windows are raised from the bottom, there will be a draft directly upon the children sitting near; while if one or two windows are lowered too much from the top, there will either be a draft in that part of the room or much dead air in the corners. The proper management of the windows is an exceedingly important duty of the teacher, and she should be expected to govern herself accordingly.

Window Boards an Aid in Ventilation. — In cold weather, so-called "window boards" are often very helpful. A window board is simply a board cut the proper length to fit closely into the bottom of the window frame when the sash is raised. This done and the sash again pulled down closely against this board, there will be sufficient air space between the two sashes at their junction to admit fresh air and to give it an upward movement in the room. This board ought not to be any wider than the height to which it would be necessary to elevate the lower sash so that the upper part of its frame would slip well past the lower part of the frame of the upper sash.

If the board be wider, it will obstruct too much of the light and also be somewhat more difficult to handle. An improvement on the one-piece board may be made in the same way as the adjustable wire screens are made, or better still in the same way as the hinged screens for sleeping cars; that is, by cutting them in the center and putting hinges on them so that they fold together. Such construction makes it easier for the teacher to adjust them in the grooves made for the window frame.

These boards should be made to fit quite snugly, for they are devices that may be depended on only in very cold weather, and not even then with a room full of children and a faulty system of heating. They are helpful, though, and may be made by the boys of the upper grades or by any department mechanic.

Open the Windows at Recess. — One of the common practices of busy teachers is to throw the windows open at recess time and, as they say, "give the room a good airing." This is wise when the children are out of the room or can move about in it freely, but it is unsafe if some of the children for one cause or another are left seated at their desks. Their health would be endangered by drafts, and often the dust would be stirred up to be breathed by the children when they return. But many teachers depend upon these few airings per day to satisfy the requirements of proper ventilation. For the benefit of the children so mistreated, I want to impress upon their teachers again some of the things already mentioned. Each child of the primary grades should be furnished with two thousand cubic feet of pure air per hour, and those of the grammar and high school grades, twenty-five hundred or three thousand cubic feet per hour. This does not mean, as we have elsewhere suggested, that each child breathes this amount of air each hour, but each one vitiates this amount and renders it unfit to breathe. If, then, a room is thirty-two feet long, twenty-four feet wide, and twelve and one half feet

high, it would contain about ninety-six hundred cubic feet of air, for a part of the space is taken by the occupants and by the desks and other furniture. If a room of this size is used for fifty children of the lower grades, it would take less than six minutes for them to vitiate all the air in it. How, then, can any thoughtful teacher, one who really cares for children, shut them up in a box of this size and "air" it only once an hour? Fortunately at such times the windows and doors, and the floors and walls, are not air-tight, otherwise there would be even more murders committed in the name of education than the vital statistics now show. But the plain truth that I want to impress is this: there must be a constant and regular supply of fresh air admitted and in such a quantity as to effect a complete change at least once every five minutes in any school building accommodating the relative number of children here mentioned. Of course, children can live in such buildings with an "airing" each hour, but they are not in condition to work and are endangering their health and stunting their bodies.

Need of Double Windows. — In the winter time in cold climates double windows are not only of great service in preventing loss of heat and precluding drafts from entering all about the windows, but they also furnish an opportunity of admitting the necessary fresh air in such a way as to scatter it fairly over the room. In the case of double windows, when the outer one is lifted a little from the bottom and the inner is lowered an equal distance from the top, a current of air will pass up between the windows, enter the schoolroom near the ceiling, and scatter more or less completely over the room. During its passage between the windows, the air will be slightly warmed by reason of its contact with the inner panes, and will, in so far, descend in the room more slowly. A modification of this double-window device consists in a small stationary supplemental upper sash on the outside, so that when the window is lowered the air cannot rush in directly, but is given

an upward movement, thus tending to prevent drafts and also to scatter the air through the room. However, care must be taken in the use of all such devices, else the best light entering the room will be interrupted and dimmed.

In some of the German schools one occasionally sees one or two upper panes of each window cut into strips and fastened in the center to a small rod and so arranged that they may be opened or closed, just as the slats on the old-fashioned window blinds are managed. By turning these at the proper angle, the entering air is given an upward movement and somewhat more equally distributed about the room.

At best, it is impossible to ventilate satisfactorily, at all times, a schoolroom with fifty children in attendance, by means of windows. The air cannot be distributed properly, drafts are frequent, wind currents cannot be managed, and above all on quiet, warm days there is no efficient cause operating to effect any adequate movement of the air either toward the room or from it.

Sometime in the more enlightened future, we shall sufficiently appreciate child life to reduce by one half the number of children now assigned to one room, and to give them all the pure outdoor air that wholesome life demands.

Gravity Systems of Ventilation. — While, strictly speaking, ventilation by means of windows and doors is ventilation by the force of gravity, we cannot with propriety speak of ventilation through windows as a system of ventilation. By the phrase "gravity system of ventilation" is meant a system devised for heating fresh air and then for regulating its admission into a room and its exit from it. In planning to furnish fresh air by means of any gravity system, it is clear that either the air must be heated before it enters the room, or else within the room itself, for no gravity system will introduce fresh air unless the atmosphere escaping from the room is at a higher temperature than the surrounding outside air, and therefore lighter. It will be seen at once, then, that a gravity system will

not work when warm days come and when the temperature outside is equal to or greater than that required in the room. The colder the outside air, the more efficient such a system is, and, *vice versa*, the warmer the outside air, the less effective.

Home Ventilation and School Ventilation Compared. — In the case of homes heated and ventilated by furnaces placed in the basements, it will be comparatively easy to meet normal demands even when the outside air is but a few degrees lower in temperature than the air within, for a small but regular inflow of fresh air and a corresponding discharge of vitiated air will go far toward keeping a home pure and wholesome. But when one undertakes to supply pure air to fifty school children, he must in all reason, as we have pointed out elsewhere, introduce at least one hundred thousand cubic feet of pure air per hour and discharge an equal amount of vitiated air and do it in such a way as to create no troublesome drafts and at the same time to keep it moving and to maintain an equable and regular temperature. This can be accomplished by a gravity system only when a sufficiently great disparity exists between the temperature of the outside air and that within the schoolroom, or when a sufficient amount of heat is applied in a thoroughly efficient system of aspirating flues. When the weather is cold, and steadily cold, a well-constructed gravity system will insure fair ventilation in schoolrooms, but under no other conditions is this practicable. Suppose, for example, the air outside is at the freezing point. The difference between this and seventy degrees Fahrenheit, the maximum temperature allowable in a schoolroom, would be thirty-eight degrees. If, under these conditions of temperature, a properly constructed gravity system of ventilation is set to work and carefully supervised, we may with some degree of assurance expect fair ventilation.

In the first place, provision for the discharge of air from the room is as necessary as for admitting it, and the exits for such discharge must be so situated as to withdraw the vitiated

air rather than the pure air just entering. Therefore it is necessary to consider the position, size, and shape of the ducts designed to admit fresh air and of those for the discharge of vitiated air. It seems to be determined with a reasonable degree of finality, all points considered, that the best position for the inlet duct, if one is used, is about eight feet from the floor a little back of the middle of the inside wall opposite the windows. This position insures: first, the minimum waste of heat due to radiation induced by cold or damp walls; second, no interference with the proper position of the windows in the room; third, it tends in most cases to shorten the necessary length of the duct from the hot-air chamber and also to prevent the necessity of making so many curves or elbows in the duct, and so materially reduces the friction as the air passes through; fourth, if the duct is placed a little to the rear of the middle of the wall, it will insure a more complete circulation of the air about all the children than if placed elsewhere, for the center of population in a schoolroom is always at a little distance back of the middle of the room; fifth, at the height of eight feet from the floor, especially if the terminus of the duct is properly made, the air can be scattered about the room with the least danger of producing drafts and the least likelihood of dislodging any dust particles clinging to the walls or ceiling.

Size, Shape, and Position of Inlet Ducts. — The size of the ducts is a most important element in the success of any system of ventilation. It is my observation that more serious blunders have been made in undertaking to furnish sufficient fresh air through ducts of inadequate capacity than in almost any other element of ventilating systems. Because air is invisible most school authorities forget to take into the calculation the fact that there is much friction in its passage through these ducts. In addition to the reduction in the amount that any duct will carry by reason of this friction, drafts are more noticeable with small pipes than with large. For it is obvious that of two pipes furnishing the same amount of air,

the larger will deliver at a slower rate per second. No rules can be given here to fit all conditions, for the changes in temperature and the varying lengths of the ducts enter into the problem so as to complicate it greatly. It is, however, easy to see that the air current in a duct three feet wide and eight inches thick must travel at the rate of more than thirteen feet per second to furnish one hundred thousand cubic feet of air each hour, and this amount, we have seen, is required for each room of fifty children. Some one may object to these figures on the basis that fifty children are too many for one teacher to manage, and therefore it is not necessary to base a calculation on this number. Fifty children overcrowd the room and overburden the teacher, but it must not be forgotten that any system of ventilation must be devised to meet the needs that the common conditions of to-day may impose. Moreover, it does not seem probable that in the immediate future classes in primary schools will be reduced much below this number. Air entering a room at the rate of thirteen feet per second is likely to produce disturbing drafts and to keep the dust afloat unless the terminus of the inlet duct within the schoolroom is so constructed as to throw the air well toward the ceiling and at the same time to scatter it well over the room before it reaches the level of the breathing line, in this way obviating any possible drafts. There seems to be no practicable possibility of enlarging the duct, and in this way reducing the rate. Indeed, it will be quite difficult to find room enough in an inner wall to accommodate a duct three feet wide, unless some special form of construction is designed to meet the need. Likewise it is very difficult to install a duct more than eight inches thick, inside measurement, and to keep its outside walls flush with the inside of the lathing; and certainly neither the halls nor the schoolrooms should be disfigured by jutting the duct out past the walls.

Of course the terminus of the duct leading into the room can be shaped so as greatly to relieve the rate and to turn

the stream of air upward toward the ceiling and laterally toward the ends of the room, but even then, at times, it will be unsafe to risk such a rate as the quantity of air required and the size of the duct would demand. For most assuredly there will be no end of complaints from teacher and pupils if there is any suspicion of drafts, and the outcome of such a condition would be an order from principal, superintendent, or school board to close the duct partially near the hot-air chamber. To be sure, the dangers from drafts are often greatly exaggerated by nervous teachers, and very often the very thing needed is more movement in the air of the room; but there are some dangers to be avoided.

Just such conditions as are here described exist in a majority of the newer school buildings that have been constructed, regardless of careful calculations. Drafts are troublesome, and even dangerous, at times, but bad air is, in the long run, more to be dreaded, especially for rapidly growing children whose nervous systems are very sensitive and most readily affected by the lack of oxygen. The necessary outcome of the calculation is, then, that it is better to have two fresh air ducts for each room, two feet wide and eight inches thick, with properly constructed flaring tops and sides and tilted gratings to direct the air upward and to scatter it thoroughly over the room. These two ducts ought to be in the inner wall and opening about eight feet above the floor. One should be about eight feet from the front end of the inner wall, while the other should be the same distance from the rear end of the inner wall. By this arrangement, with the form of opening mentioned, sufficient air can be scattered so as to prevent the possibility of drafts and "dead air" anywhere in the room, especially if the exits are properly placed and of sufficient size. The placing of the exits is not an easy matter, for "short circuiting" the incoming currents of air must be avoided and a thorough mixing of the air accomplished. The exits must then be, in the main, on the same side of the room as the inlets to meet

these requirements most perfectly, and they should open near the floor.

Arrangement of Exit Ducts. — At this point I wish to describe an arrangement of exit ducts that has proved entirely satisfactory in some thoroughly modern school buildings. It is well to say, however, that the arrangements described are, in the main, in connection with the plenum fan system, but I can see no reason why they would be less satisfactory than any other placing for a gravity system, providing, of course, the draft in the exit flues is aided by exhaust fans, gas jets, or some other method of heating. One exit, according to these plans, should be placed near the floor, about twenty feet from the cloak room and in the inner wall of the schoolroom, while the other is to be placed about eight feet from the floor in the inner end of the cloak room situated preferably immediately behind the teacher's desk, or, if exigencies of construction demand, at the other end of the room. But the air is to find its way to this latter exit by passing through openings in the lower third of the doors of the cloak room. By this arrangement, warm air circulates through the whole length of the cloak room, at a level with the wraps, and then passes out. At first thought, it might seem that this would not offer sufficient opportunity to change the air thoroughly in that corner of the room on the left of the teacher as she faces her pupils, and also that it would offer a chance for "short circuiting" over the heads of the pupils seated in the front of the room. But when one stops to consider the amount of friction that the current of air would have to overcome in passing through the cloak room, he can readily see that this would largely counteract any such short circuiting in this direction. Furthermore, according to the plans in mind, the door from the hall would open into the schoolroom near the corner on the teacher's left and would offer a chance for the entrance and the escape of sufficient air to keep up the requisite circulation in this somewhat sparsely inhabited part of the room.

The value of this method of ventilating the cloak rooms cannot easily be overestimated, for on damp, rainy days, the wraps are all dried and warmed and the possible odors from them have no chance of reaching the schoolroom. The danger from infection is lessened, and the discomfort and risk of wet wraps is reduced to a minimum. It will be remembered that we have elsewhere (see Chap. III, p. 38) called attention to this position of the cloak room as one designed to take advantage not only of this method of ventilation, but also to give the teacher easy control of the cloak room and to reduce to a minimum the possibility of pilfering.

The exit near the middle of the inner wall of the schoolroom should be open and constructed somewhat after the fashion of a wide, rather low open fire place. I wish here to make a special plea for care and thoughtfulness in the construction of this opening. If it be provided with a grating, it will invariably become the receptacle of bits of paper, dust-covered lint, and specimens of all the débris that finds its way into any schoolroom. If left open, it must be strongly and neatly constructed so as neither to suffer from occasional bumps nor to offend the eye. It seems needless to say that no opening, either inlet or exit, should ever be made in the floor, for no amount of care could keep such openings hygienic and prevent the incoming air from lifting a cloud of dust into the room. Recently some authorities have objected to passing air from the schoolrooms, through the cloak rooms, as here recommended, maintaining that the foul air should not come into contact with the clothing. The dangers suggested by them seem to be overestimated, for with sufficient ventilation the air passing through the clothing cannot be of such a nature as to leave any resulting bad effects. Naturally it would be better if a separate supply of pure air could be driven through the cloak rooms, but the probability that this can be done is very remote. The plan suggested is feasible and practicable, and the dangers so remote that little harm is possible.

Aspirating Flues. — The next question to consider, after the size, form, and location of the ducts have been decided upon, is the proper construction of the aspirating flues. These are significant in any system of ventilation, but especially and vitally so when the amount of air introduced depends wholly upon the force of gravity. Obviously, if no mechancial force is to be used, the vent ducts carrying off the vitiated air from the schoolrooms and cloak rooms must connect with some outlets to the upper air, and these must be so constructed and so heated as to create a draft sufficiently strong to exhaust approximately 100,000 cubic feet of air per hour from each room. The higher the top of an aspirating flue is above the room from which it draws its air supply, other things being equal, the less heat it will take to produce the required draft. But, from an architectural point of view, the height of such flues is limited by the height of the building, for it is not practicable to extend them more than a few feet higher than the roof.

Hence, ample provision must be made to create a vigorous and regular draft in these flues in order to exhaust the vitiated air and to permit the free entrance of pure air. Many methods have been devised to this end, but they have in most cases been inadequate because of the unwillingness of architects and schoolmen to incur the expense in construction and in operating necessary to insure success. In a twenty-room school building depending upon a gravity system of ventilation, there should be at least four large aspirating flues so situated that the ducts from the various rooms can lead into them as directly as possible and at an upward angle, for every curve or bend in a duct means added friction and lessened value. The main difficulty and expense comes in keeping the air in these exit ducts at a considerably higher temperature than that in the room. Many attempts have been made to reduce the expense of this heating process by running the smoke pipe from the furnaces through the center of these aspirating

flues and by depending on the heat from such a pipe to heat the air about it. In general, this method is a failure, first and chiefly, because in warm weather very little if any fire is kept in the furnaces, and, second, because the smoke stack by reason of its situation in the center of the flue, creates an undue amount of friction with the ascending currents of air. It is far better, where buildings are heated by steam, to install a series of steam coils in these flues and to depend upon the radiation from these to heat and to discharge the currents of vitiated air. These coils should be placed a short distance above the inlet of the foul air ducts so as to prevent any retarding effects due to direct radiation.

No further specific direction in regard to the aspirating flues seems worth while here, for each school building offers its own special problems, and should be studied and planned by a competent architect — not merely a builder — who knows how to subordinate everything to the health and comfort of the generations of children involved.

For the country schools or the small village schools where it is impossible to install a good central system of heating, the best aid to ventilation, aside from the proper use of the windows, is the so-called "jacketed stove." These may be purchased now in almost any market, and serve not only to introduce fresh air and warm it as it comes in, but also to protect the children who, of necessity, sit near the stove. A good-sized jacketed stove, properly conditioned, will introduce on cold days a fair amount of fresh air, but of course it is useless for purposes of ventilation in warm weather.

In order to get the best results with a stove of this sort, it is necessary to have an extraction flue into which the vitiated air of the room can be drawn by means of a draft created therein by an open fire or a flue-heating pipe. This extraction flue should open near the floor on the inner wall, if possible, and on the same side of the room as the stove. The jacket, as suggested above, should be higher than the stove, slightly

flaring at the top, and should completely inclose the stove save at the door, through which the fire receives its fuel and its draft of air. The inlet duct should be sufficiently large to render the passage of the air free and easy, and the jacket should spread a little at the base and fit snugly to the floor. It is best, too, to construct the building in such a way that the floor joists will run toward an outer wall and thus prevent cutting them to admit the inlet duct. (For further discussion of the "jacketed stove," see the chapter on "Heating.")

But when all is said and done, there is no good and adequate excuse for installing an expensive gravity system of ventilation in any large school building, unless such a building is situated in a cold climate and the school session is limited mainly to the cold months of the year. It is my opinion that, during even medium cold weather, it is safer to depend for ventilation on windows than upon any gravity system yet developed.

Mechanical Means for Ventilation. — By a mechanical system of ventilation is meant a system of ducts, inlets, and exits arranged, as we have indicated under a former topic (see page 152), and in addition a fan or fans so arranged as to drive the air in (the plenum system), to pull it out (vacuum system), or both to drive it in and at the same time, by means of a suction fan, aid in creating a draft in the exit ducts. There are some advantages and disadvantages in each of these systems, and, without entering too much into detail, let us examine them separately.

The Plenum System of Ventilation. — The plenum system, as its name indicates, is devised to drive the fresh air into the schoolroom and to depend on this force alone in warm weather to crowd out the vitiated air. Under these conditions the air in the schoolroom will be of somewhat greater density than the outside air at the same elevation, providing that the temperature in the room is equal to that outside. But since, for a large part of the school year, the air outside may be colder than

that within, the difference in density will be so slight as to be practically negligible, so far as its sensible effect on breathing is concerned especially if the exit ducts offer as little friction to the escaping air as their proper construction should insure. Seeing, then, that the air in the schoolroom has a slightly greater density with the plenum system, it is clear that during calm weather this makes it possible to control the source from which fresh air is admitted. There is a leakage, but this leakage is always away from the schoolroom rather than toward it. That is to say, all of the air entering a schoolroom under these conditions of necessity comes through the ducts directly connected with the fan and from a selected source. This offers opportunity, if there be need, to filter the air so as to remove dust and dirt, to moisten it if it is too dry, to warm it if it is too cold, or to remove some of its moisture if it is too humid. For example, if for one reason or another a school building must be placed near a busy street or a dusty roadway, the plenum system, if properly installed, would permit all the fresh air to be drawn from the side farthest removed from the street, hence insuring cleaner and purer air than could be secured by any other system. Provision may also be made, and should be made if conditions warrant, to draw the air through an opening some distance from the ground, thus further obviating the danger of dust and also reducing the possibility of contaminations by avoiding the vitiations usually contained in the ground air.

Naturally it will require less force to deliver a given amount of fresh air in a schoolroom when the entering air is warmer than the air outside, but by the use of the plenum system air can be forced in and made to circulate in the room and escape therefrom even if the outside air is as warm or warmer than that within. This fact is of the greatest importance, for no system of ventilation will meet all requirements if it is not capable of insuring an adequate supply of pure air regardless of relative temperatures.

Source of Air for Plenum System. — Architects and school officers too frequently give no thought to the source from which fresh air is to be supplied until the site for a building is chosen, the plans drawn, and the building is in process of construction. Then it is usually too late to make amends.[1] No janitor will be able to keep such a building clean, until some method of filtering the dust out of the air is installed, or unless the intake for the fresh air is moved to the rear of the building and high above the level of the street. But even if the janitor can find a way to remove the dust at the close of each day, during the school session the children must breathe dirty air and suffer the consequences. Apparently many architects have not yet learned that one of the most vital elements in any schoolhouse plan is that which has to do with adequate and rational ventilation.

Large Fans Needed. — One serious mistake is often made in installing the plenum system by selecting fans too small to do the work required of them without running them at a high rate of speed. A large fan properly constructed and carefully set while running at a low speed rate will deliver the amount of air required without making any appreciable noise, or setting up any noticeable vibrations. On the other hand, if the fan is so small that it must be run rapidly to introduce the requisite amount of air, it is likely to set the air into rapid vibrations and communicate to the various rooms with which it is connected a buzzing noise, which, at times, is very troublesome and annoying. Furthermore, the wear and tear incident to the rapid motion of a fan will in a short time offset the difference in the initial cost between it and a larger one, not to mention other trouble and delays. No rules can be given here

[1] I have in mind at this time an expensive and, in the main, well-planned school building, situated near a busy street, from which clouds of dust are stirred up at frequent intervals and, to make matters worse, the architect actually set the fans to draw the air from the street side of the building, and near the ground at that.

that will apply with equal exactness to all kinds of fans, for the amount of air that they will deliver depends not alone on their size, but also upon their form of construction. When school authorities are planning to install such a system, the only safe thing for them to do is to put in a fan system sufficiently large to insure an adequate supply of pure air in each room under all conditions when the fans are running at a moderate rate of speed. False economy will often dictate another course, but no honest engineer or agent will knowingly recommend such procedure.

Location of Fans. — There are decided advantages in the plenum system too, growing out of the fact that the fan or fans may be placed in the basement, while in the exhaust system these are most economically managed and run when set above the rooms to be ventilated. When fans are situated in the basements, they can with greater ease and much less expense be firmly embedded in the cement floor and so disconnected from the main structure that no vibrations or jarrings will be produced when they are running. When fans are placed in the attic, they are too far removed from the janitor for careful supervision, for most of his time during school hours must of necessity be spent in the basements, overseeing the furnaces, the closets, etc., and keeping things in repair. It is far easier and hence more economical to have all the machinery within easy reach and quick control. But the most important advantage of the plenum system grows out of the fact that, when properly installed, one cannot only control the source of all the air delivered to the schoolrooms, barring the effects of adverse winds, but can easily measure the amount delivered, and in this way he may be certain of the degree of purity or impurity of the air that the children must breathe. On the other hand, when the exhaust system is in use, air will come into the room through every possible opening, bringing dust and whatever bad air may lurk in the vicinity of such openings. Moreover, it is much more difficult, if not practically impos-

sible, to measure the amount of air drawn into a room by an exhaust fan, for, as we have said, under such conditions air will be forced into the room through every possible opening, and on windy days will create havoc with any heating and ventilating system.

The Effect of Winds on Ventilating Systems. — Thus far we have taken no specific account of the wind and its effect on ventilation, and all too frequently this variable is not considered at all. But all who have had any practical experience in striving to maintain proper heat and equal distribution of fresh air in buildings where ventilating arrangements are the same for exposed and unexposed rooms, will appreciate some attempt to correct this difficulty.

In the first place, school buildings are by no means impervious to the passage of air through the walls and ceilings as well as about doors and windows. But where rooms have unilateral lighting and consequently nearly half of the outer wall surface is used for windows, it is patent that especial care is needed to see that these fit closely in order to prevent the warm air in the room from escaping, as well as to prevent the cold air outside from being blown into the building. In cold climates double windows are economical as well as hygienic necessities. These are perhaps as important, too, on the leeward side of a building as on the windward. When the wind strikes a building, the amount of air *driven into it* on the windward side will depend on the aggregate of cracks and crevices for it to enter, the amount of air pressure or lack of it in the room, the force of the wind, and the angle at which it strikes the building. On the leeward side, the amount *exhausted from it* will depend on the aggregate of cracks and crevices through which the air may be drawn out, the amount of air pressure or lack of it in the room, and the suction power of the partial vacuum created by the cleavage of the wind by the building. On the windward side a strong plenum condition, or high pressure of the air in the rooms, will operate to resist the inflow of the air

from without. On the other hand, a similar high pressure condition in the rooms on the leeward side will aid materially in the exhaust set up by the low pressure condition outside. And here we have a principle any practical ventilating system must meet. On the windward side a greater pressure is needed within, and the currents of air must be driven in at a higher speed rate to overcome the resistance of the currents forced in by the wind. Moreover, since it is evident that under normal plenum conditions a smaller amount of air will be driven through the exhaust outlet than will come in through the inlet duct, the relative size of these ought to vary to suit the demands. For example, on a calm day we can expect less outflow through the exhaust ducts than is driven in through the inlet ducts, for under a plenum condition some of the air, indeed much of it, will often find an exit about the windows or even through the walls. But as pointed out above, this is all changed in windy weather; for then on the windward side it is evident that more air will be exhausted than is supplied through the inlet duct unless some handicap is placed on the exhaust duct or an undue plenum condition is maintained. On the other hand, on the leeward side the reverse condition will take place, and more air will be driven in through the fresh-air duct than will pass out through the exhaust duct, for the reason that the low pressure without on this side will cause much air to escape around the windows and through every possible crevice in the wall and ceiling. Hence, on this side, additional draft is needed through the outlet duct to maintain the proper circulation and the consequent purity of the air at the breathing line.

Tests made by Mr. H. W. Whitten and others, and reported by him at a meeting of the American Society of Heating and Ventilating Engineers held at Indianapolis in 1909, make the above discussion more explicit. He says: —

"A few typical tests made by the writer and others during the past winter in this connection should be of interest.

"The first test is of a school building, rectangular in shape, the ends of the building facing north and south, having stairway windows *only* in these ends; east and west sides divided into schoolrooms, each having five windows five feet wide by nine feet high, window sills on a level with tops of pupils' heads when seated; windows having usual clearance; rooms heated by a fan system designed to supply 1800 cubic feet of air per hour per pupil with inlet velocity of 750 feet per minute; wind northwest, velocity 14.5 to 15 miles per hour; outside temperature 33 degrees. Room No. 5 situated on the east side of first-floor building, one room removed from south end, showed an average rate of supply velocity of 817 feet per minute and a vent velocity of 340 feet per minute. Inlet and outlet of same size. Inlet eight feet above floor, outlet at floor and both on opposite side of room from windows. This showed a loss of 457 feet per minute. An air test of this room showed ten parts of carbon dioxide in 10,000. This loss was practically all above the breathing line, and frequent complaints of headaches among scholars occurred.

"Other rooms on the east side of building showed as follows: —

	Rate of Supply	Rate of Ventilation
First floor, Room No. 3	760	410
First floor, Room No. 6	753	396
Second floor, Room No. 13	690	315
West Side:		
First floor, Room No. 7 (partly sheltered)	660	700
Second floor, Room No. 14 (exposed to strongest wind effect)	410	705

"Temperature Control in Use in the Building

"Average temperature east rooms at the breathing level, 73°; at floor, 70°. Average temperature west rooms at the breathing level, 68°; at floor, 58°.

"A test of another school building with wind at eighteen miles per hour and outside temperature 30 degrees, building heated and ventilated by gravity indirect system, showed an average of 20 per cent loss from the supply ducts in rooms on the windward side and an addition of 60 per cent to the vent velocity.

"Rooms on the leeward side of the building showed an addition of

3 per cent from the supply velocity and a reduction of 62 per cent of the vent velocity.

"A school building having a few corridor windows on the north side, and schoolroom windows on the east, south, and west, was tested with typical results, as follows: Wind, twenty miles per hour; direction, northwest. Room No. 26 on east side of building, two movable windows seven feet wide by nine feet high, one tight window ten feet wide by nine feet high, sills level with breathing level. Inlet eight feet from floor, four feet from east wall, volume of air supply 2340 cubic feet per minute; volume of air passing out vent, 1451 cubic feet per minute.

"Room No. 28, south side of building, near east end, windows same as No. 26; volume of supply, 1862 cubic feet per minute; volume of air passing vent, 1311 cubic feet per minute."

A test made by Mr. A. B. Franklin of Boston and the Massachusetts district police on a school building some years ago is also interesting.

"Wind twenty-five to thirty miles per hour, and blowing toward a majority of windows in the building: —

Room Number	Air Supply at Inlet per Minute	Air Vent Outlet per Minute
11 (exposed)	1,536	2,367
12 (exposed)	1,533	2,307
13 (exposed)	1,996	2,838
14 (exposed)	2,244	2,990
15 (partly sheltered)	2,200	2,368
16 (partly sheltered)	760	805
20 (exposed)	1,694	2,391
21 (partly exposed)	2,517	2,777
22 (partly exposed)	1,609	2,031
23 (partly exposed)	2,253	2,762
24 (partly exposed)	1,389	1,653
25 (partly sheltered)	2,301	2,288
30 (partly exposed)	1,984	2,394
31 (exposed)	568	1,154
32 (sheltered)	1,602	1,773
Hall (sheltered)	7,833	5,786
35 (partly sheltered)	2,153	2,442
34 (partly sheltered)	1,863	2,148
36 (exposed)	933	1,404

"A high school building was recently tested by Professor H. C. Anderson of Michigan University, there being some question as to whether the heating contractor had put in a competent apparatus (fan system). The supply seemed of sufficient quantity and temperature, but rooms on the exposed sides of the building could not be satisfactorily heated. After shutting down the fan the supply ducts were closed in the rooms on the exposed side of the building, and, with all doors and windows closed, it was found that as much air was being removed from the vent ducts as the fan system was supposed to supply. During this test the outside wind was of moderate velocity.

"Tests of several buildings in which the leakage about outer openings had been standardized by means of a metal expansion joint showed an average difference between supply and vent flow of 10 to 15 per cent, the greater part of this being due to difference in temperature of air at these points." [1]

It is obvious that the amount of variations here reported, will not only explain many troubles, but that these results will necessitate new calculations and improved devices to overcome the difficulties. It is to be hoped that additional experiments of a like kind will be made in different parts of the country and under different conditions of temperature and wind velocity. The results of these experiments will, as it seems to me, render the further installation of exhaust fans in school buildings altogether questionable, unless they can be disconnected from the ducts coming from the windward side of the building. It would be of great service on cold, windy days if an exhaust fan could be attached to the ducts exhausting the air from the rooms on the leeward side; but since the winds are so variable, two exhaust fans would be necessary to meet this demand. The exit ducts would have to be arranged accordingly, and the fans run or not according to the direction and velocity of the wind. There are two practical suggestions growing out of this discussion that may be utilized especially in the country and in villages. Windbreaks in the way of trees and hedges at the

[1] See *School Board Journal*, October, 1909, p. 13. A shorter report may also be found in *Engineering Record*, Vol. 60, No. 10, p. 264.

proper distance on the north and west side of school buildings, especially those of one story, would greatly lessen the difficulties experienced on cold, windy days. But a more practicable suggestion and one within the reach of those who build schoolhouses is this: count on trouble from cold winds and see to it that the walls of school buildings are as impervious to currents of air as they can well be made, and insist on close-fitting window frames and double windows where needed.

Further discussion of the plenum system at this point seems unnecessary, for the architect and school boards must settle the size, style, and number of these systems for each individual building. The matter ought to be emphasized, however, in every pertinent way possible. School boards are derelict in the performance of their duty when they do not get and pay for expert service in planning a fan system of ventilation for each style of building erected, when they fail to specify in their contracts the exact requirements of each, and especially when they do not insist on careful tests to determine whether or not their contract has been fulfilled before final payment and acceptance is voted.

In this connection it may be well to repeat that an anemometer should be a part of the equipment of every school system, for it does not require much practice or any expert calculations to determine at any time the efficiency of a plenum system in the rooms with which it is connected. This instrument is simply a small windmill geared to a dial attachment by means of which the rate of a current of air may be determined readily. Hence, by knowing the rate of the incoming current under given conditions, and the size of the inlet duct, the quantity of air delivered in a given time may be readily calculated. The only special precaution needed is to make a sufficient number of tests at various places over the entrance orifice to get a mean rate as a basis for calculation. Other means of excluding error will readily suggest themselves to any principal or superintendent capable of managing a system of schools.

Tests to determine Efficiency of Ventilation. — The school superintendent or principal who cannot wait for expert tests must have some means of testing the air of schoolrooms, to determine the effectiveness of the ventilating system, or to meet objections urged from time to time by patrons and the public in general. One of the best methods of indirect estimation of impurities in the air of the schoolroom is the sense of smell. Let the superintendent send the teacher from a room where the air is foul into the fresh air for a few minutes, and then ask her upon returning to the schoolroom whether she finds the air pure. The sense of smell is fatigued very rapidly, and to the teacher who has been confined in the room the air may not seem bad, as it must to one who enters a badly ventilated room from the fresh air. Such a test, of course, furnishes no figures as to the relative proportions of carbon dioxide and oxygen, or of the amount of deleterious gases of any sort; but it does furnish unmistakable evidence as to whether the air is wholesome or unwholesome, pleasant or unpleasant, to breathe.

Another indirect method consists in determining the amount of fresh air furnished to each pupil per minute or hour, and in calculating on the basis of this supply the relative purity of the air in the room. This method is practicable only when the plenum system of ventilation is used, when there are no disturbing winds, and when an anemometer is available. Under these conditions any careful observer may get fairly accurate numerical results.

There have been a number of specific methods devised to determine the amount of carbon dioxide in the air of the schoolroom, but for the most part they are either too complicated for the ordinary teacher to use successfully without a good deal of practice, or else, if simple, they are not sufficiently accurate to give reliable information. Of these tests, but two will be described here, and either of these can be used to advantage after a little practice by any ordinary careful teacher. The results obtained from several experiments may

be sufficiently accurate to warrant certain definite conclusions regarding the effectiveness of any system of ventilation.

Chemical Tests. — The apparatus devised by Wolpert is simple and consists of a chart, a test tube of given size and shape, and a rubber bulb of known capacity fitted with a glass tube. On the bottom of the test tube there is painted a black mark, and around the tube a little more than an inch from the bottom a ring for measuring purposes is ground in the glass. The tube is usually supported in a simple frame. When the tube has been thoroughly cleaned, and the requisite amount of a saturated solution of lime water poured into it, air is then gathered from the room by means of a rubber bulb and forced through the lime water. The percentage of carbon dioxide in the air may then be determined from the chart by noting the number of times the bulb must be emptied before the water reaches such a state of cloudiness as to make the black mark invisible as one looks down through the water. It requires some skill to empty the bulb without splashing the water or without withdrawing some of the water as the bulb is removed. With care, results may be obtained that will warrant a conclusion, especially when the air contains an undue amount of carbon dioxide.[1]

The Fitz method, devised by Dr. W. G. Fitz, of Harvard, is more complicated, but after the liquid required has been prepared, it may be used easily and rather quickly. This apparatus and the method of testing the air may be described briefly. There are six small vials of a given dimension fitted with rubber corks. These are to hold the solution used to make six tests. Larger tubes of special size and make are furnished in which a given amount of the air of the schoolroom can be mixed with a vial of the solution. By reference to a table furnished, the percentage of carbon dioxide may be determined. The liquid used consists of a weak solution of

[1] The set is inexpensive and may be purchased from Codman and Shurtleff, Boston.

lime water containing a few drops of phenolphthalein. The exact proportions to be used and the methods of preparing the solution are explained in the directions accompanying each set. My experience with this test shows that although the directions are not clearly stated, when used with care, and when all the conditions are properly met, it will give more regular and accurate results than the Wolpert method.[1] The apparatus and the materials used in each of the tests mentioned above require little or no knowledge of chemistry on the part of the experimenter. In the hands of any careful observer they may be very helpful in connection with the hygienic supervision of schools.

TOPICS FOR INVESTIGATION

1. How long would it take forty children of the sixth grade to render the air in a schoolroom thirty-two feet long, twenty-four feet wide, and twelve and one half feet high unfit to breathe, all doors and windows being shut, and no wind blowing? On the basis of your answer calculate the amount of air that should be introduced into this room each minute.

2. What physical principle is the basis for all forms of gravity systems of ventilation?

3. Work out for your schoolroom the best possible methods of ventilation with the conditions furnished. Give reasons for the methods preferred.

4. Under what conditions of body, of humidity, of temperature, and window openings are drafts to be especially avoided? Other things equal, is a draft from an entirely open window more or less dangerous than one striking the body from a window slightly opened?

5. Is night air necessarily any more dangerous than midday air? How did the prejudice against night air grow up?

6. State clearly all the advantages and disadvantages of each of the methods of mechanical ventilation.

7. Note the effect on the attention and interest of children and adults who are confined in churches, theaters, schools, or public assembly rooms of any sort, without sufficient pure air.

[1] The set is prepared by L. K. Knott Apparatus Co., Boston.

8. Study the effects of the winds on the heating and ventilation of your schoolroom.

9. Why does proper circulation of the air in a schoolroom bring much relief?

10. Find the most practicable and reliable test that you can use to determine the purity of air in a schoolroom.

SELECTED REFERENCES

BILLINGS, J. S. *Ventilation and Heating.* New York, 1893. 500 pp., illus.

CARPENTER, R. C. *Heating and Ventilating Buildings.* New York, 1896.

MORRISON, G. B. *The Ventilation and Warming of School Buildings.* New York, 1887. 181 pp.

Report of Special Committee, American Society of Heating and Ventilating Engineers. *Heating and Ventilating of Schools.* Metal Worker, Plumber, and Steam Fitter, v. 77, pp. 570–572. 1912.

THOMSON, W. G. *Ventilation Problems in Hospitals and Schools.* The Heating and Ventilating Magazine, May, 1912, pp. 11–16, and June, 1912, pp. 21–25.

WINSLOW, C. E. A. *The Scientific Basis for Ventilation Standards.* Proc. N. E. A., 1911. pp. 977–985.

FIG. 30.

FIG. 31. - Open-air school, Refectory Building, Boston. Why not more of this for healthy children? (Courtesy Boston School Committee.)

CHAPTER XII

OPEN-AIR SCHOOLS

The Beginnings for Open-air Schools. — The movement for open-air schools, both in this country and in Europe, grew out of the success attained in the treatment of tuberculosis and scrofulous diseases in camps and open-air sanitariums.

At first these schools were called vacation camps or forest schools. The first buildings were constructed in the form of covered sheds with one or more sides left entirely open. They were usually located in forests, parks, or gardens, and used only in vacations during the warm months. The idea gradually developed, as the good influence of such treatment was observed, that, if the fresh air was so helpful to those seriously afflicted, it ought to be furnished in the same way to the anæmic and weaker children, who were still able to attend the regular schools. Here the idea of prevention entered and this is now becoming the prevailing consideration in the organization and development of this movement. It has been determined that, while forests and gardens are valuable adjuncts, an open-air room on the roof of a city school building, or even a reconstructed or remodeled room within such a building, will serve fairly well for this purpose. The main requisites are fresh, clean air, comfortable surroundings, good food, and something interesting to do.

Special Clothing needed in Cold Climates. — In the beginning these schools or camps were in session only during the warmer months of the year, but the fear of cold air is gradually giving way, and now many open-air schools are in session through the winter. Naturally special wraps and clothing are necessary to keep the children comfortable and at the same

time to allow them sufficient freedom for work. Fig. 32 shows an open-air schoolroom in Chicago in cold weather, and the peculiar "Eskimo suit" evolved for the children.

"These Eskimo suits are simply double-breasted pajamas cut from heavy woolen blankets. They are to be worn over the other clothing, large sizes being used and the legs and sleeves shortened to fit the individuals. To the collars are fastened hoods with tape so placed as to tie snugly about the face in severe weather. The outfit is completed by a pair of heavy felt boots, the soles covered with material like the suit, with a thick interlining of paper."[1]

Some open-air schools, notably in Providence, Rhode Island, provide, in addition to special suits, sitting-out bags and warming stones for the feet.

The use of the latter, however, seems necessary only in very cold weather if due care is taken to have the feet warm and shoes dry before putting on the outer suit. Of course the clothing best suited to any locality will depend on the climatic conditions.

There seems to be no reason why such rooms should be left without a roof, or at least some covering that may be adjusted to keep out rain, sleet, and snow. This would render the problem of clothing much easier to solve. The only possible objection that can be made to a permanent roof is the loss of sunshine during midday.

Semiopen-air Rooms. — It is not necessary to build a special building in order to start an open-air school. Any schoolroom may be turned into a semiopen-air school, if it has good exposure and hinged windows. Experience has proved that a good method of hinging the windows is to fasten them to the top of the frame, and by means of a pulley and cord lift them inward and upward to the ceiling. Naturally this will necessitate strong sashes all in one piece, and fitted at the

[1] *Open-air Crusaders*, a report of the Elizabeth McCormick Open-air School, edited by Sherman C. Kingsley, and published by the United Charities of Chicago, 51 La Salle St.

FIG. 32. — Not afraid of a Chicago winter. From *Open-air Crusaders*, Elizabeth McCormick Open-air School, Chicago.

bottom and sides, so that when closed they protect the building from beating rains. A better arrangement will doubtless be possible in some buildings.

It may often prove an advantage to begin with the use of such a room, so as not to encounter opposition at once. Here the anæmic children from the whole building, regardless of grade, may be gathered, and they may serve as a constant

FIG. 33.—Winter dress for the teacher of an open-air school.

object lesson to the whole school. Comparatively little expense need be incurred in starting the movement, in this way.

Apparatus and Furniture needed, and Examination of Children Important.—Some provision must be made for movable and adjustable desks, chairs, tables, and, in cold weather, for convenient wraps and blankets. In addition to necessary furnishings in the room itself, the principal, if he expects to determine with any exactness the effects of fresh air on such

children, must make careful notes of the height, weight, general physical condition, and appetite of the children at the beginning, and as often as necessary throughout the experiment. Platform scales carefully adjusted will be needed from the first, and the children should be weighed at least twice a week.

The teacher for such a room must be selected because of her sympathy with the movement, and must know how to adjust herself to a new order of things. She ought to keep record of all that would show good or evil effects upon the children; in fact, she ought to be a trained nurse as well as a trained teacher. The medical inspector, where such an officer exists, will naturally take the initiative in directing both teacher and principal in all that pertains to the physical welfare of such children, and make a record of the results of a more technical diagnosis from time to time.

Benefits of Open-air Schools and Sleeping Porches. — In the long run the greatest benefit from open-air schools will come as a by-product. People should learn the value and necessity of pure air, and the open-air school will be the most effective agency and apostle in proclaiming this doctrine. The cities of the southeastern and south central divisions of our country will have little difficulty in turning rooms of their school buildings into open-air rooms, if they will properly orientate their buildings, and make larger windows with hinged sashes so that they may be thrown open. Due to the fact that the south still has large forests and extensive vegetation everywhere, abundance of sunshine, and less smoke and dust than almost any other part of the country, the outside air is low in carbon dioxide and rich in oxygen. And yet because the people live in houses badly ventilated and often constructed so as to bar the sunshine from living rooms and bedrooms, and also because disease germs have more time during the year to do their work in this moist climate, tuberculosis is making terrible ravages. The people all over this land, especially in the south, ought to be taught to build sleeping rooms on open balconies,

FIG 34.—Christmas in an open-air school in San José, California.

well protected from mosquitoes, and once for all disavow the superstition that night air is dangerous to breathe. Some one has said that the only night air that is dangerous is last night's air.

In hot moist climates the restfulness of cooling breezes is alone an abundant compensation for the expense incurred in building outdoor sleeping rooms. But the wholesome and invigorating results of breathing pure air during sleep will multiply this compensation many fold. Each country school-teacher ought to include in her general lessons on hygiene a discussion of the value of outdoor sleeping rooms, and suggest simple plans for their construction. When the people are taught the value of fresh air, schools will have less difficulty in securing proper appliances for ventilation, and fewer anæmic children with whom to deal.

Outdoor Work an Aid in Teaching. — One interesting discovery has been made in connection with teaching in those open-air schools situated in forests or parks, and that is the fact that so much advantage can be taken of the immediate surroundings for illustrative and teaching material. In nature study, geography, history, and all those studies that have to do with physical environment, stronger direct appeal can be made than when the children are in regularly constructed schoolrooms. It has been found that even the teaching of arithmetic can be made far more concrete and personal when the children measure distances, calculate the size of trees, and other objects near at hand, and make computations on these results. But these are only by-products; the real helps come through better health, gain in weight, and added hæmoglobin in the blood.

Resulting Benefits of Open-air Schools in Other Countries. — The reports on open-air schools in Germany, England, and in this country show conclusively that a very large percentage of the children who have attended these schools for a reasonable length of time were much improved in health and general

physical vigor. Three English open-air schools, with two hundred thirty pupils in attendance from sixteen to nineteen weeks, reported in 1908 that careful tests made at the beginning and end of the term showed that all save nine of the pupils gained hæmoglobin; that one hundred and one gained from 10 to 20 per cent, and sixty-eight gained 20 per cent or more. The gain in weight was also striking; but as the children were given a different diet and perhaps in greater abundance than that to which they had been accustomed, these gains might, in part, be accounted for in this way. The fact, however, that many gained in a few weeks at a rate much above the normal goes to prove the assumption that the chief cause of the rapid increase of weight was the fresh air, wholesome sports, and the general air of quiet freedom all about them. The gain in hæmoglobin in the blood is especially significant. It means greater capacity of the red corpuscles to carry oxygen to the tissues, and this implies a higher type of activity throughout the whole body.

One of the important features of open-air schools as they are managed in England consists in the midday rest and sleep period. This usually occupies about two hours, during which

FIG. 35. Rest after luncheon. Elizabeth McCormick Open air School, Chicago. (From a photograph by the author.)

the children in proper weather are placed upon cots in the open air. If cots cannot be provided, heavy canvas spread on the grass will serve the purpose. A small pillow may be used, and when the air is chilly, some covering is necessary. From such treatment a large proportion of the children gain in general

FIG. 36. — Open-air school work. Shrewsbury House, Woolwich, England. (Courtesy Education Committee, London County Council.)

health and vigor, as evidenced by the reports of their regular teachers and parents as well as by those of the medical officers.

Along with the increased demand for open-air schools in cities and villages, in foreign countries, so-called "vacation colonies" have brought relief to many children. This plan consists in sending a group of children from cities, usually in the long vacation period, into the country for a fortnight or so of schooling at the expense of local public authorities or local charity organizations. Sometimes the school authorities afford no further help than that incident to the employment and compensation of the teacher. In Germany and France this method has for the past two or three years brought some relief to thousands of city children whose home life offers little opportunity for wholesome, clean living.

TOPICS FOR INVESTIGATION

1. Why is it that country folk are likely to criticize teachers who undertake to do part of their regular school work out of doors? How may such objections be most readily overcome?

2. Devise ways and means for introducing some regular outdoor school work during good weather.

3. Collect pictures and drawings showing the construction of open-air school buildings, sleeping porches, and summer camps.

4. Collect all the statistics that you can get with reference to the effect of fresh-air schools upon the health and vigor of the teachers and pupils.

5. Are people naturally better adjusted to living in doors or out of doors? Why?

6. Why is there less danger from a draft out of doors than in doors?

7. Under what conditions are colds most readily contracted? Why?

8. Is the following prophecy of the Massachusetts Association for the Prevention and Control of Tuberculosis likely to come true at an early date? "The time is coming and is not far off when all children will be in open-air rooms, and all schools will be open-air schools."

SELECTED REFERENCES

AYERS, L. P. *Open-air Schools.* New York, 1910. 171 pp., illus.
BALLIET, T. M. *Open-air Schools and the Children who should benefit*

from Them. Report III Congres International d'Hygiene Scolaire. Paris, 1910. pp. 310–315.

BRANNAN, JOHN W. *Open-air Schools in the United States.* Proc. American School Hygiene Association, 1911. pp. 177–181.

CARRINGTON, T. S. *How to build and equip an Outdoor School.* Survey, v. 24, pp. 144–151, illus.

KINGSLEY, S. C. *Open-air Crusaders.* Chicago, 1910. 107 pp., illus.

WATT, W. E. *Open Air.* Chicago. 282 pp.

CHAPTER XIII

HEATING OF SCHOOLROOMS

Proper Temperature for a Schoolroom. — The question, What is the proper temperature for a schoolroom? cannot be answered satisfactorily simply because conditions in our country are so varied.

In some parts of the country where the outside temperature is never very low, and the humidity high, a temperature of sixty to sixty-five degrees in the schoolhouse is more satisfactory than in other parts where the outside cold is severe, and where, by reason of the lack of moisture in the heated air, a temperature of from sixty-eight to seventy degrees is required.

In England, where the climate is moist and moderate, rules prescribe as the maximum sixty-five degrees. In parts of our country, by reason of the lower temperature in winter and the consequent low humidity of the air when raised to a temperature high enough to satisfy the demands of teachers and pupils, the minimum must be raised in some places as high as seventy degrees Fahrenheit in order to maintain comfort.

Loss of Heat from the Body. — Our bodies have great power to maintain the normal temperature of the blood and tissues. Heat is being constantly produced in the living organism, and if this heat had no way of escaping, it would rapidly increase until life would be impossible. On the other hand, if we had no means of retaining the heat in very cold weather, equally disastrous results would occur.

In cold weather we increase our clothing and build fires. In hot weather we reduce our clothing, and in various ways accelerate the loss of heat. In general heat escapes from our

bodies in the three following ways: by radiation, conduction, and evaporation.

If you were to heat an iron on a stove and then remove it, it would soon grow cold. The heat from it would escape chiefly by radiation and conduction. If you were to hold it close to your face, you could feel the heat waves leaving the iron. If you were to bring it into contact with a piece of cold metal or ice, it would rapidly lose some of its heat by conduction. In addition to these methods of losing heat our bodies perspire, and as this moisture evaporates the temperature of the skin is reduced, for it is a principle of physics that evaporation from a surface always tends to reduce its temperature. We are always surrounded by air, and the condition of the air has to do, directly, with the loss or retention of heat in the body. If the air is cold, and there is much moisture mixed with it, heat escapes from our bodies at a rapid rate, chiefly as the result of radiation and conduction. This explains why cold and damp weather is so "penetrating." If the air is mild and *dry*, radiation and evaporation are rapid. Hence we can stand a high temperature, if there is little moisture present, better than a much lower temperature with much moisture.

In the hot valleys of California or Arizona, the air is very dry in summer, and the heat intense. But it is very rare to hear of any one being overcome by the heat. It is less dangerous to work there in a temperature of one hundred ten degrees Fahrenheit than it would be in a moist climate with a temperature at ninety-five degrees Fahrenheit.

In general, then, when the air is moist and warm, the body loses its heat slowly, but when it is dry and warm it loses its heat more rapidly. Hence it is necessary to maintain a higher temperature in schoolrooms under the latter condition than the former in order to be comfortable. It is plain, therefore, that the proper temperature for a schoolroom will depend, in part, upon climatic conditions where the school is situated. A temperature of sixty-five degrees Fahrenheit is satisfactory

if the air is moist, but it will not be comfortable if the air in the room is dry and harsh.

Well-constructed Buildings greatly simplify the Problem of Heating. — A building with single floors and badly constructed walls demands greater variations of heat than one constructed on hygienic principles. One with thin, open floors will show such variations in temperature between the floor line and the breathing line that children would suffer in cold weather even if a temperature were maintained that would be entirely comfortable in a better building.

The Relation of Clothing to Temperature Required. — The kind of clothing worn by the children and teacher enters into the problem. Children furnished with proper underclothing naturally require less artificial heat to maintain comfort than those more thinly clad. The teacher, as far as possible, ought to take this fact into account when matters of heating are under her control.

The Age of the Pupil a Factor in Heating. — The younger children, especially those who have more adipose or fatty tissues surrounding their bodies, need a lower temperature in schoolrooms than those who are not so protected against cold. For this reason, other things being equal, boys suffer more from cold and generally require thicker clothing than girls.

The Nature of the School Work a Factor in Heating. — Where the body is active, more heat is produced than when it is quiet, and hence if the work of the schoolroom is so organized as to demand of the pupils greater activity, the temperature of the room may be reduced. Manual-training work, gymnastic exercises, and other lines of work making demands on the muscles, call for lower temperature than quiet, seat work.

The Kind of Food supplied is also an Element in the Artificial Temperature Required. — In the cold countries of the Arctic region the people eat a great deal of fat. This is not a mere matter of taste and food supply. One gram of fat will liberate more heat in the body than two grams of carbohy-

drates (sugars, starches, cellulose, etc.), and hence these people demand much fat for food, in order to develop and maintain the required heat in their bodies.

Children who eat meats and butter, other things being equal, require less artificial heat to maintain a comfortable body temperature than those whose diet includes less fats.

Local Conditions must be Considered. — In general it may be said that no definite and exact degree of temperature can be prescribed for schoolrooms, for local conditions must always enter into the problem. Because England and the countries of continental Europe, especially Germany, France, and Holland, set a lower minimum than we, it does not necessarily follow that we are in error when we set a higher limit. Experience has taught us that during cold weather it is often necessary for us to maintain a temperature of sixty-eight degrees in our schoolrooms, or else prescribe special clothing for children to wear while at study, if we would keep them comfortable. But, as already shown, this will depend on many factors, and especially the amount of moisture in the air. If we could do away with the desert-like air of our schoolrooms and furnish pure air with normal moisture, we could reduce the temperature, and at the same time be comfortable.

Methods of Heating Schoolrooms. — In the following paragraphs short accounts are given of the various methods of heating, and the relative values of each. The reader must understand, however, that no attempt has been made to treat these exhaustively. The books and articles referred to at the close of the chapter ought to be consulted by those teachers and school officers who are seeking more critical and extended information on this topic.

The Open Fire. — One of the best, but also one of the most expensive, methods of heating a room in a well-constructed dwelling house is by means of the open fireplace. It is best because it furnishes not only heat, but also excellent ventilation. In earlier days this was the common means of heating

schoolhouses; but it was wasteful of fuel, and required much care. The open fireplace as the sole source of heat supply has almost vanished from schools as well as from homes.

Out of twelve hundred ninety-six rural schools, recently reporting to the United States Bureau of Education from nineteen states, only one reported a fireplace. Attention is called to the fact that the open fire in a school, when it is properly cared for, so as to reduce the danger from setting fire to the building, may be made a very valuable auxiliary to any method of heating. It aids in ventilation, furnishes an opportunity to dry wet clothing and shoes, to take off a slight chill in the air when a fire in a furnace, or under a boiler, would raise the temperature too high; and it creates a circulation in the air and thereby renders a general system of heating more effective. It furnishes cheer, and makes a schoolroom seem more homelike.

Heating with Stoves. — About half of the country and village schools are still heated by the ordinary box stove, usually situated in the center of the room. Under such conditions it is impossible for teachers to regulate the temperature of the schoolroom properly. Those children who sit close to the stove suffer from heat, or else those at a distance suffer from cold. Except on very mild days when little fire is needed, it is impossible to maintain an equable temperature in all parts of the room. Some relief, in cold days, may be had by keeping a vessel of water on top of the stove, and in this way introducing more moisture into the air; but the use of the box stove for heating schoolrooms ought to cease, because better methods are now available.

The Jacketed Stove. — The ordinary box stove may, at little expense, be turned into a jacketed stove. This may be done by moving the stove to a corner of the room, surrounding all sides of it save the door with a sheet-iron casing, set six or eight inches from the stove, and connecting this space with the outside air by means of a carefully constructed fresh-air duct. The jacket ought to fit closely to the floor, and about the

door of the stove, and extend a few inches above the top of the stove. As the stove is heated, the air about it will lighten through expansion, and rapidly pass upward into the room;

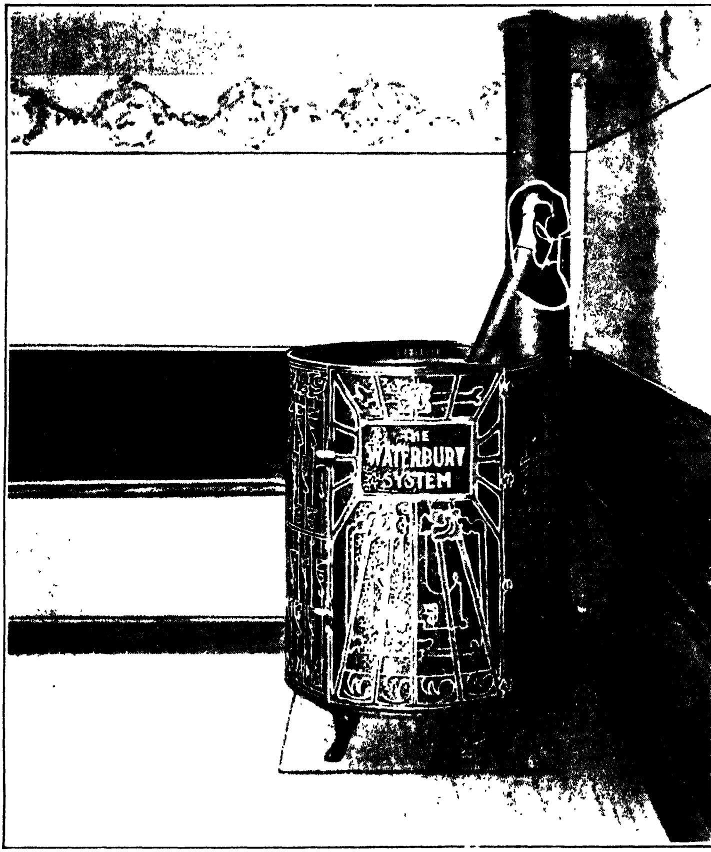


FIG. 37. – A jacketed stove.

while the fresh air from outside will rush through the duct to take its place. This cold, fresh air will keep the stove from overheating, and at the same time, when warmed, will enter

the room. A circulation of air will thus be established, which will tend to equalize the temperature in all parts of the room.

There are on the market now a number of specially made jacketed stoves that are much more satisfactory and sanitary than any transformed box stoves can be made.

Fig. 37 shows the construction of one of these stoves. In this case, however, instead of the fresh-air duct entering under the stove, it comes in through the wall above the floor, and enters the jacket in such a way as to distribute the incoming air all about the heating surface. The fresh-air duct is not visible on this cut, but it enters through the wall directly facing the observer. The large pipe, extending almost to the floor to the right of the stove, is the foul air exhaust. The small pipe emerging from within the jacket at the top of the stove, and entering the larger pipe a short distance above the top of the jacket, is the smoke pipe from the heater within the jacket. This small pipe, as may be seen, continues upward through the larger pipe, to prevent danger from sparks dropping down the larger pipe to the floor, and trouble from lack of draft in the heater.

Jacketed Stoves as Aids in Ventilation. — Any observant person who will study the construction of this stove will readily see that in *cold* weather there will be a rapid inflow of air through the fresh-air duct and out into the room from the top of the jacket.

He will also see that the larger pipe, visible at the right, is designed for the escape of air from the bottom of the room, by reason of the heat applied through the smoke pipe running up through this larger pipe. Hence this stove is designed not only to furnish warm, fresh air, but also to help rid the room of foul air, and thus maintain a circulation of fresh air, near the breathing line.

Jacketed Stoves are not Effective as Ventilators save in very Cold Weather. — Advertisements of jacketed stoves that emphasize their effectiveness as ventilators are often

misleading and false. No jacketed stove now on the market will or can aid to any appreciable degree in ventilating schoolrooms in mild weather, for it is obvious that if little heat is needed, little fresh air will come in. These stoves are effective as heaters; and although they cost more than they should, they are to be recommended in all cases where furnaces, hot-water, or steam heaters are not practicable.

About one third of all rural and village schools in the country are now supplied with jacketed stoves. They are, however, far more common in the North than in the South.

Heating by Hot-air Furnaces. — Strictly speaking, the only essential differences between a hot-air furnace and a jacketed stove are these: the jacket to the furnace terminates in one or more closed ducts leading to rooms above; and is therefore always designed to be located on a lower level than any room that it is intended to heat. It is placed in basements, and is supplied with fresh air through a shaft or duct connected with the outside air at a higher level. The furnace is a central heating plant and possesses advantages over a jacketed stove, in that it is removed from the schoolroom and is designed to furnish heat to a number of rooms.

The Advantages and Disadvantages of a System of Hot-air Furnace Heating. — Briefly and untechnically stated some of the advantages of this system of heating are as follows: (1) It aids materially in securing ventilation in cold weather. (2) It is cheaper to install than any other system of central heating. (3) It requires less technical skill to manage than either steam or hot water. (4) It is better adapted to mild climates where there is need to raise the temperature comparatively few degrees; and especially where a little heat is needed in the mornings, and none, or comparatively none, at midday. (5) It requires no special attention during holidays in cold weather, as steam and hot-water heaters do. (6) It offers opportunity to introduce moisture into the air without much expense.

Some of the disadvantages may be stated as follows: —

(1) There is danger that as the result of faulty construction, or warping by overheating, some of the gases liberated by combustion in the fire box may pass through into the air ducts leading to the schoolrooms.

(2) Overheating or "scorching" the air as it comes into contact with the outer surface of the fire box, or combustion chamber.

(3) It is liable to rather rapid fluctuations unless heated by oil, or by a uniform fire.

(4) It is not effective in very severe weather unless a very large heating surface is available.

(5) It is generally more expensive in fuel requirements.

In those sections of our country having mild winters the hot-air furnace is, however, one of the most satisfactory systems available for heating small or medium-sized school buildings. The chief difficulties encountered, aside from those mentioned, have arisen from the fact that furnaces are often improperly installed. A furnace badly located, and supplied with air ducts not properly proportioned to insure an equal distribution of heat to the various rooms of a building, will always cause trouble and dissatisfaction. But this difficulty may be avoided, if those who install a furnace are both honest and exact in the calculations needed to make the ducts of the proper size, and to place them properly. All school authorities should insist on disinterested, professional advice before installing a hot-air furnace.

Steam Heating. — The use of low pressure steam as a means of heating large school buildings, especially those situated in cold climates, has increased rapidly in the past decade. Some of the advantages of this method of heating classrooms may be stated as follows: —

(1) The boiler room may be in a disconnected building, and one set of boilers may be made to serve several buildings.

(2) Steam furnishes a comparatively steady heat, and may

be managed for direct heating by radiators in the room to be heated, indirect heating by warming fresh air to be conducted to the rooms, or by a combination of both methods.

(3) It furnishes an easy method of proportioning heating surfaces to the rooms.

(4) It does not scorch the air.

(5) It is fairly economical, and the heat may be easily distributed.

There are also some disadvantages: —

(1) It requires trained engineers to operate it economically and safely.

(2) It is not economically adapted to mild climates, or to mild weather conditions.

(3) It requires constant care during cold weather, whether school is in session or not.

(4) In case radiators are used in the schoolroom, they are often sources of "hammering" noises.

(5) Repairs are often frequent, and there is always danger of leakage.

Steam-heating apparatus requires more care and gets out of order much oftener than any other system now in general use, save perhaps the hot-water system. This is due to the fact that the radiators, of which a great number are required, are often quickly heated and as quickly cooled; thus by rapid expansion and contraction joints are opened, and these are often hard to close. Moreover, the boiler requires expert care in order to minimize the danger incident to the use of confined steam, and to guard against deterioration through the accumulation of sediment and precipitations. Leaking flues and steam fittings require the expensive services of expert mechanics.

Hot-water Heating. — In the main what has been said concerning the difficulties with a system of steam heating will apply to hot-water heating. One distinct advantage of a hot-water system over steam lies in the fact that it is more satisfac-

tory in mild weather, since, in order to secure a circulation of water in the pipes, it is not necessary to heat it to as high a temperature as cold weather requires, to supply sufficient heat. This would not only serve to economize in fuel, but would make it possible for the janitor to do a large part of the regulation of the temperature in the rooms by means of the intelligent adjustment of fires. Another advantage of hot water lies in the fact that it gives a more regular supply of heat, of a more acceptable quality than either the steam or the hot-air furnace provides. But it is a slow method, and for climates subject to sudden and decided fluctuations in temperature, it is unsatisfactory for school purposes. There are some disadvantages as compared to steam occasionally overlooked. It seems to require better joints to avoid leakage than does steam, and this may mean much trouble. By reason, too, of a slower rate of circulation due to lack of central pressure, there is more danger of unequal distribution of the heat. This, however, may be overcome in large measure by proper grades, or by suction pumps properly connected with the return pipes. But pumps necessitate a separate steam-power plant or motor to run them.

Thermostats. — All modern systems of indirect heating of school buildings depend on some form of thermostat to regulate the temperature of the schoolrooms. A thermostat is a device for regulating the mixing of the warm and cool air to be delivered to a classroom. If a thermostat is set to maintain a given temperature, say sixty-eight degrees Fahrenheit, and the air in the rooms registers less, the thermostat will automatically cut off cold air through the inlet duct, and will open the damper to give free entrance to the warm air. If the temperature of the room goes above sixty-eight degrees Fahrenheit, then the opposite action will result. Cold air will be given preference. By the careful use of thermostats in connection with indirect heating, the temperature of a schoolroom may be automatically regulated so as to vary not more than

two degrees. Thus great relief to busy teachers and to pupils is possible, and an observant fireman may make much reduction in fuel bills. No modern school building is complete without some effective thermostat system.

TOPICS FOR INVESTIGATION

1. By the use of a hygrodeik, hygrometer, or sling psychrometer, determine the humidity of the air in the schoolrooms under your supervision during various conditions of the weather, and note the difference in the temperature required for comfort.

2. Is it possible to set an exact maximum or minimum temperature for schools in all parts of our country? Why?

3. Determine the variations in temperature during cold weather in different parts and at different levels of your schoolroom. To what causes are such variations due?

4. What is the best location for a thermometer in your classroom, all things considered?

5. If direct radiation is used in a classroom, where should the radiators or stove be placed?

6. Taking all things into consideration, which is best for schools, heating by direct radiation, indirect radiation, or a combination of both methods?

7. Work out clearly whether furnace, steam, or hot-water heating would best suit the climate in which you are teaching. Give adequate reasons for your conclusions.

8. Determine clearly what physiological conditions must be met in order to ascertain the proper temperature for schoolrooms, at a given humidity percentage.

9. In general is the temperature ordinarily found in our schoolrooms too high or too low?

10. Make a careful study of the effectiveness of the various kinds of heating apparatus found in the schools in your state. Compare the costs of installation, repairs, and fuel in all such systems.

SELECTED REFERENCES

BALDWIN. *Steam Heating Data*. New York, 1897. 365 pp.

BILLINGS, J. S. *Ventilation and Heating*. New York, 1902. 500 pp.

BRIGGS, W. R. *Modern American School Buildings*. (Chap. 11.) New York, 1909. 411 pp.

CARPENTER, R. C. *Heating and Ventilating Buildings.* New York, 1910. 562 pp., illus.
CLAY, F. *Modern School Buildings.* (Chap. 25.) London, 1906. 555 pp.
JACOB, E. H. *Ventilation and Warming.* London, 1894.

CHAPTER XIV

HUMIDITY IN THE SCHOOLROOM

Air does not absorb Water. — We are told by Professor Marvin that it is "a false notion that *air* has a certain capacity for moisture," and that it is wrong to say that "the air is partly saturated with moisture." "It should always be clearly observed," he continues, "that the presence of the moisture in any given space is independent of the presence or absence of air in the same space except that the air retards the diffusion of the vapor particles. It is more correct to say that the *space* is partly saturated with moisture, or that the moisture is in a partly saturated condition or is superheated." He therefore advises the use of the phrase "weight of a cubic foot of saturated aqueous vapor," not "weight of aqueous vapor in a cubic foot of saturated air." [1]

Need of Humidity in Schoolrooms. — The amount of aqueous vapor present in the air to be delivered to schoolrooms is a matter of much direct importance to the health and to the comfort of the pupils and teachers. The dry, harsh, desert-like condition often found in schoolrooms is both unpleasant and unhygienic. Such a state of dryness offers little hindrance to the escape of the moisture from the body, and especially from the lining membranes of the air passages, leaving them dry and harsh. As remarked elsewhere (see p. 195), this condition is favorable for attacks of pathogenic germs, for, without their coating of mucous exudations, these delicate tissues are directly exposed. When the normal habitual and hygienic amount of moisture is present, there is neither that unpleasant harsh-

[1] See *Psychrometric Tables*. W. B. No. 235, U. S. Department of Agriculture, Weather Bureau, p. 8.

ness that irritates the temper as well as the skin, nor will it be necessary to maintain as high a degree of temperature for comfort. When the normal amount of aqueous vapor is mixed with the air, the rate of evaporation from the body will be lowered and the accumulated heat in the body will render a lower temperature of the air entirely comfortable. Thus it is highly advisable not only from the point of view of health and comfort, but from economy of fuel to supply our schoolrooms, especially in winter, with a larger percentage of moisture properly mixed with air. But it may be argued that a dry climate, such as abounds for a good part of the year in the semi-arid regions of the southwest part of our country, is very healthful as evidenced by the great numbers of sick people who annually seek health in such climates and often with success. Hence why not keep the air of the schoolroom dry even if it does parch the skin and dry up the moisture of the air passages? This question may be answered by saying that in these dry arid climates there are few pathogenic germs or bacteria of any sort floating in the air, and the air is not so dry as in most schoolrooms on cold days. In parts of the region mentioned a piece of fresh meat may hang for days in the air with a temperature of 70° F. without spoiling. This could not be the case even in mild weather in the atmosphere of a moist climate.

A parched throat and dry nasal passages in a moist climate will have to run many more risks of infection than where the air is warm, but almost free from disease germs. In cold, moist climates, if a child leaves a schoolroom heated to a temperature of 68° F. with harsh skin and dry passages, and goes out into a cold, moist air, there are not only dangers due to sudden chills, but to infection by the germs of influenza, pneumonia, diphtheria, etc., which are almost always lodged in the air passages awaiting their opportunity. The irritation of the lining membranes thus produced gives them the needed opportunity.

TABLE A

MONTHLY MEAN RELATIVE HUMIDITY AT THE HOURS OF 7 A.M., 2 AND 9 P.M., LOCAL MEAN TIME, AT THE STATIONS NAMED BELOW (1878–1880)[1]

Station	January			February			March			April			May			June		
	7.	2.	9.	7.	2.	9.	7.	2.	9.	7.	2.	9.	7.	2.	9.	7.	2.	9.
New Bedford, Mass.	94	69	90	94	76	89	88	72	89	81	62	85	79	62	86	80	68	87
Woods Hole, Mass.	79	72	76	79	74	78	78	68	77	77	67	78	75	67	81	79	72	86
Newport, R.I.	76	65	73	78	66	75	77	65	74	78	62	75	77	61	77	80	66	80
New London, Conn.	79	67	77	77	63	75	76	63	75	74	59	75	73	62	76	78	66	80
Oswego, N.Y.	78	69	75	76	67	72	75	63	71	72	63	70	74	59	68	79	65	73
Utica, N.Y.	—	—	—	—	—	—	—	—	—	80	—	80	84	—	82	85	—	80
Charlotte, N.C.	83	62	72	76	50	61	73	47	62	71	44	61	72	46	64	67	45	63
Wilmington, N.C.	82	56	74	78	50	71	79	48	72	76	46	73	80	55	77	79	55	77
Atlanta, Ga.	78	61	69	68	49	58	68	46	56	69	48	58	72	48	62	69	47	61
Augusta, Ga.	83	61	77	78	49	65	78	44	65	76	46	67	74	43	67	73	43	64
Mobile, Ala.	88	64	80	83	57	76	85	55	77	81	56	77	83	57	79	80	59	77

[1] See *Report on the Relative Humidity of Southern New England and Other Localities*, by Alfred J. Henry. Bulletin No. 19; W. B. No. 97, U. S. Department of Agriculture, Weather Bureau, p. 20.

TABLE A — *Continued*

MONTHLY MEAN RELATIVE HUMIDITY AT THE HOURS OF 7 A.M., 2 AND 9 P.M., LOCAL MEAN TIME, AT THE STATIONS NAMED BELOW (1878–1880)

STATION	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	7.	2.	9.	7.	2.	9.	7.	2.	9.	7.	2.	9.	7.	2.	9.	7.	2.	9.
New Bedford, Mass.	86	70	90	87	71	91	91	75	91	89	69	86	92	68	85	92	78	19
Woods Hole, Mass.	83	78	87	86	75	88	84	72	83	80	67	75	75	65	72	78	71	75
Newport, R.I.	80	65	82	83	69	84	85	68	82	81	64	76	79	66	73	78	68	77
New London, Conn.	79	69	84	82	69	84	84	70	84	80	61	77	76	62	72	75	66	74
Oswego, N.Y.	76	60	73	81	62	73	81	61	73	77	60	71	76	66	72	78	72	75
Utica, N.Y.	86	—	85	85	—	84	91	—	88	81	—	80	84	—	79	—	—	—
Charlotte, N.C.	76	51	70	84	62	78	80	51	70	80	51	71	79	54	69	82	60	73
Wilmington, N.C.	82	59	79	86	66	84	86	59	80	86	56	81	83	56	78	82	58	75
Atlanta, Ga.	73	52	65	84	60	76	81	57	70	79	58	71	76	57	65	79	61	69
Augusta, Ga.	76	48	70	82	55	76	81	54	75	83	56	76	83	58	77	82	58	70
Mobile, Ala.	82	63	81	89	56	85	86	58	82	87	62	82	88	64	84	86	70	82

Russell says: "Influenza, typhus, relapsing fever, smallpox, whooping cough, croup, pneumonia, not only prevail most in cold weather, but in cold countries where there is least outdoor life and least fresh air in rooms and most crowding. Diphtheria increases with the cold weather of autumn, but tends to decline in February, and is at a minimum during the hot months."[1]

Amount of Moisture mixed with the Air. — The amount of moisture in the form of vapor found with the air varies greatly in different localities at different seasons of the year, and at different hours during the day. From a series of investigations made by Professor Alfred J. Henry of the Weather Bureau, the table on pages 196 and 197 is taken to show the variations in relative humidity in a number of different places, at different months of the year, and at different hours during the day.

The most striking feature of this table, from our point of view, is the regular decrease in the humidity during the warm part of the day, that is, during school hours. "The diurnal variation," he says, of relative humidity in its simplest phase (p. 13) is as follows: "The maximum takes place during the early morning hours, and the minimum from 1 to 4 P.M., being simply the inverse of the daily temperature changes." Naturally this table represents conditions as they exist out of doors and under varying degrees of temperature.

The main trouble with reference to lack of humidity in connection with furnace air supplied to schoolrooms during cold weather comes from the fact that only a small amount of aqueous vapor can exist with cold air, and when this cold air with even its maximum humidity is heated and expanded the relative percentage of saturation is greatly decreased. At a temperature of twenty degrees Fahrenheit no more than about 1.235 grains of water in the form of vapor can find lodgment in

[1] See *The Atmosphere in Relation to Human Life*, Francis Albert Rollo Russell, Smithsonian Report, 1896, p. 272.

a cubic foot of space. But when the temperature reaches sixty-eight degrees Fahrenheit, there may be found as much as 7.48 grains. But if the air at twenty degrees Fahrenheit is raised to sixty-eight degrees Fahrenheit without furnishing any opportunity for additional moisture, and is forced into the schoolroom under these conditions, we can at once see that there will be only a little over one seventh of the amount of vapor required for saturation. If sixty per cent of saturation is taken as the average or normal condition of the outside air, and this you will see by reference to the tables is too low for the places named, then in order to bring the humidity in the schoolroom to this amount of saturation it would be necessary to introduce mechanically into each cubic foot of air an amount of aqueous vapor equal to 2.37 grains. If for each child twenty-five hundred cubic feet of fresh air is needed each hour to keep the air pure, then a little over one pound of water, less the amount evaporated from the body and given out through the medium of expired air in the form of vapor, ought to be introduced each hour per pupil in order to maintain sixty per cent saturation in the schoolroom. In very cold weather this percentage of saturation would probably cause moisture to gather on the windows, and in time would serve not only to hinder the light, but by reason of its precipitation, and probable revaporization near the windows, the percentage of saturation would tend to increase. The results of experiments made in Boston under the direction of the Board of Education seem to warrant the assertion that from forty to fifty per cent of saturation is desirable on very cold days. Their report says: "It was found that on mild, bright days, even a higher per cent was permissible, but on cold days it was objectionable in some rooms. . . . On the sunny side with 50 per cent moisture there was very little condensation on the windows. On the shady side it was objectionable, and the teachers complained of a dampness in the air. This was probably due to the extra cooling of the air next windows and walls on the shady side, which

tended to raise the percentage of humidity in part of the room to perhaps 70 per cent or more." Summing up their conclusions on the question, "How high a percentage of moisture is desirable?" they say, "Considering buildings, then, as a whole, about 40 per cent humidity in very cold weather and 50 per cent in ordinary winter weather seems about right." This estimate seems very low when compared with those made by authorities on hygiene. Wilson says, "In a room well ventilated and warmed the humidity ought to range between 73 and 75 per cent."[1] On just what basis he made this estimate he does not state; but he was writing primarily for the conditions that prevail in England.

If we wish to raise the temperature of a cubic foot of air from twenty degrees to sixty-eight degrees Fahrenheit with as much aqueous vapor mixed as a temperature of twenty degrees Fahrenheit will permit, and at the same time to offer no opportunity for the entrance of any further moisture, we will have a moisture in this warmed air with less than twenty per cent saturation. But if, as is much more likely to happen, when the outside air has a temperature of twenty degrees, the moisture present is only a seventy per cent instead of complete saturation, then such air raised to sixty-eight degrees Fahrenheit without additional moisture, will contain in the neighborhood of twelve per cent saturation, a condition not found even in desert air.[2]

Moisture increased from the Body. — This question now presents itself: how much moisture would be drawn from the skin and breath of school children if they were at work under such a condition? In other words, how much rise in per-

[1] See *Handbook of Hygiene and Sanitary Science* (Eighth Edition), George Wilson, M.A., M.D., etc., p. 152.

[2] These calculations are based on Table XIII, pp. 83–84, of W. B. No. 235 of the U. S. Department of Agriculture. This very interesting bulletin was prepared by Professor C. F. Marvin, and is entitled *Psychrometric Tables for Obtaining the Vapor Pressures, Relative Humidity, and Temperature of the Dew Point.*

centage of moisture could we count on after such air was warmed to sixty-eight degrees Fahrenheit and driven into the room? It is manifestly impossible to answer this question with any reasonable degree of accuracy, for the conditions are so variable as to forestall anything like a generally accurate estimate. In the first place, the rapidity of the circulation of the air in the room would be the largest variant factor. If the air remained unchanged for some time, that is if circulation of the air were impeded for any reason, naturally the moisture would continually increase up to the saturation point. If the air moved into the room and out again at such a rate as to entirely change the air from five to six minutes, then it is clear that the rise in moisture would be less rapid and would not reach a high percentage. Most texts on physiology declare that expired breath is completely saturated with moisture. Howell says: "The expired air is warmed nearly or quite to the body temperature and is nearly saturated with water."[1] But surely this can only be true under normal conditions. It does not seem possible that the skin will continue to give off as much moisture after it has been exposed to dry air for two hours as it did when entering such air. Neither does it seem at all probable that the lining tissues of the air passages, parched and dry from rapid evaporation, would supply the regular amount of moisture both on account of cell fatigue and the overdemands made on the supply of water in the tissues. However, if we calculate on expired breath containing a saturation of moisture, and the temperature of the expired air at ninety-five degrees Fahrenheit, there would be thrown into each cubic foot of expired air the difference between 17.124 grains (the amount of moisture in complete saturation at ninety-five degrees Fahrenheit) and the amount received in the pure air introduced plus the amount thrown out from the skin. Neglecting for the moment the amount gathered through evaporation, we would have 17.124 grains less 1.235 grains, the amount with which we

[1] See *Textbook of Physiology*, W. H. Howell (Second Edition), p. 613.

started, or less than sixteen grains to distribute in one hundred cubic feet; for under hygienic school conditions we ought to be supplied with one hundred times more air than we breathe. Each expired breath contains a hundred times more carbonic acid gas than pure air contains, and hence one breath will vitiate one hundred other possible breaths. This would add .16 grain to each cubic foot of the twenty-five hundred needed for each pupil of the high school or upper grammar grades, totaling less than 1.30 grains of moisture in each cubic foot. With the temperature at sixty-eight degrees Fahrenheit and the amount that the air held before warming, this addition would increase the amount of moisture to a saturation of less than twenty per cent. If this percentage of saturation were raised to twenty-five, it would certainly cover all the added moisture thrown out in the breath and through the skin. Hence, under a satisfactory system of heating and ventilation, with the air of the room changing completely every five or six minutes and the temperature maintained at sixty-eight degrees Fahrenheit, the amount of moisture in the air under the conditions assumed would not total one half the normal amount. This is why on cold days the air of the schoolroom irritates and parches.

Method of determining Humidity. — In this rather long and tedious calculation only two conditions have been considered. What about all the others? How can we know the degree of saturation at any time?

The instrument used by Professor Marvin in his investigations, and generally recommended by other writers on this subject, is what is usually called a wet and dry bulb hygrometer. He calls it a "sling psychrometer." Figure 38 is a reproduction of this instrument as given in his bulletin, referred to above. The description and the method of using it are given in his own words: —

Sling Psychrometer. — "This instrument consists of a pair of thermometers provided with a handle, as shown in Fig. 38, which permits the thermometers to be whirled rapidly, the bulbs being thereby strongly

affected by the temperature and moisture in the air. The bulb of the lower of the two thermometers is covered with thin muslin, which is wet at the time an observation is to be made."

The Wet Bulb. — "It is important that the muslin covering for the wet bulb be kept in good condition. The evaporation of the water from the muslin always leaves in its meshes a small quantity of solid material, which sooner or later somewhat stiffens the muslin so that it does not readily take up the water. This will be the case if the muslin does not readily become wet after being dipped in water. On this account it is desirable to use as pure water as possible, and also to renew the muslin from time to time. New muslin should always be washed to remove sizing, etc., before being used. A small rectangular piece wide enough to go about one and one third times around the bulb, and long enough to cover the bulb and that part of the stem below the metal back, is cut out, *thoroughly wetted* in clean water, and neatly fitted around the thermometer. It is tied first around the bulb at the top, using a moderately strong thread. A loop of thread to form a knot is next placed around the bottom of the bulb just where it begins to round off. As this knot is drawn tighter and tighter the thread slips off the rounded end of the bulb and neatly stretches the muslin covering with it, at the same time securing the latter at the bottom."

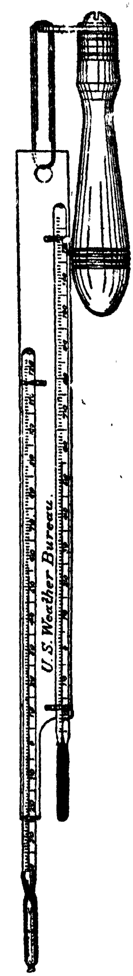


FIG. 38. — From W. B. No. 235. U. S. Department of Agriculture, Weather Bureau (Courtesy of Weather Bureau.)

To make an Observation. — "The so-called wet bulb is thoroughly saturated with water by dipping it into a small cup or wide-mouthed bottle. The thermometers are then whirled rapidly for fifteen or twenty seconds, stopped, and quickly read, the *wet bulb* first. This reading is kept in mind, the psychrometer immediately whirled again, and a second reading taken. This is repeated three or four times, or more if necessary, until at least two successive readings of the wet bulb are found to agree very closely, thereby showing it has reached its lowest temperature. A minute or more is generally required to secure the correct temperature.

"When the air temperature is near the freezing point, it very often happens that the temperature of the wet

bulb will fall several degrees below freezing, but the water will still remain in the liquid state. No error results from this, provided the minimum temperature is reached. If, however, as frequently happens, the water suddenly freezes, a large amount of heat is liberated, and the temperature of the wet bulb immediately becomes 32°. In such cases it is necessary to continue the whirling until the ice-covered bulb has reached a minimum temperature."

Whirling and stopping the Psychrometer. — "It is impossible to effectually describe these movements. The arm is held with the forearm about horizontal, and the hand well in front. A peculiar swing starts the thermometers whirling, and afterward the motion is kept up by only a slight but regular action of the wrist, in harmony with the whirling thermometers. The rate should be a natural one, so as to be easily and regularly maintained. If too fast or irregular, the thermometers may be jerked about in a violent and dangerous manner. The stopping of the psychrometer, even at the highest rates, can be perfectly accomplished in a single revolution, when one has learned the knack."

He further cautions the experimenter to so handle the instrument that it will not be influenced by sunshine or the presence of the observer's body. To get rid of this latter possible source of error, he suggests that the experimenter move slowly so as to keep the thermometers in territory not affected by the moisture or heat from the body. Having performed the experiment and having obtained a satisfactory reading of the difference in temperature between the wet and dry bulb thermometers, what is the next step? Here certain tables must be supplied from which the percentage of saturation may be read. In order to make these as brief as possible, I have selected those parts of sets of tables that will probably cover all conditions arising in the tests made in the schoolroom.

How to use the Tables. — The first thing to do is to find out approximately the stage of the barometer at the time of testing. This can generally be found out from the local weather reports if no barometer is accessible in the immediate locality. If the plenum system of ventilation is used, some slight allowance may be made for higher pressure in the room.

But as the difference is likely to be but a very small fraction of an inch, for practical purposes this difference may be neglected. If the barometer registers between 29.6 to 30 inches, then use the table marked "Pressure = 30.0 inches." When it registers anywhere between 28.6 and 29.5, use the table marked "Pressure = 29.0 inches." Suppose, then, we have found by the use of the psychrometer that the difference in reading between the wet and dry bulb is 10.5 degrees Fahrenheit, and the temperature by the dry bulb is 68 degrees Fahrenheit, and the barometer 29.8, how can we find the relative humidity? Turning to the table for "Pressure = 30.0 inches," and to sixty-eight in the air temperature column, by following this line through to the last column in that part of the table that shows "Depression of the wet-bulb thermometer $(t-t')$," we find that the relative humidity per cent of the schoolroom is fifty-two. Take another example: Suppose we have found that the difference in the readings of the wet and dry bulbs in the schoolroom is 17.5 degrees, the temperature of the room as shown by the dry-bulb thermometer is 70 degrees Fahrenheit and the barometer is 29.3, what is the relative humidity? Turning to the lower part of the table marked "Pressure = 29.0 inches," we find seventy in the air temperature column, and follow this to the right until we reach the fourteenth column headed 17.5, and we find the relative humidity to be twenty-eight per cent. If it should happen that, in certain elevated parts of our country, these tables do not meet the requirements of barometric pressure, it will only be necessary to get a copy of Dr. Marvin's bulletin mentioned above to find extended tables for all probable conditions indoors and out. By the use of these larger tables it will be possible to determine the humidity outside or inside through a large variation of temperatures and barometric pressure. The bulletin will cost ten cents and ought to be in the hands of all who undertake any extensive experiments in determining relative humidity.

TABLE B

Relative Humidity, Per Cent — Fahrenheit Temperatures

Pressure = 29.0 inches

Air Temp. t	Depression of Wet-bulb Thermometer ($t-t'$)																				
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
60	97	94	92	89	86	84	81	78	76	73	71	68	65	63	61	58	56	53	51	49	46
61	97	94	92	89	86	84	81	79	76	74	71	68	66	64	61	59	56	54	52	50	47
62	97	94	92	89	87	84	81	79	77	74	72	69	66	64	62	60	57	55	53	50	48
63	97	95	92	90	87	84	82	79	77	74	72	70	67	65	62	60	58	56	53	51	49
64	97	95	92	90	87	85	82	79	77	75	72	70	68	66	63	61	58	56	54	52	60
65	97	95	92	90	87	85	82	80	78	75	73	70	68	66	64	62	59	57	55	53	50
66	97	95	92	90	87	85	83	80	78	76	73	71	68	66	64	62	60	58	55	53	51
67	97	95	92	90	88	85	83	80	78	76	73	71	69	67	65	62	60	58	56	54	52
68	97	95	93	90	88	85	83	81	78	76	74	72	69	67	65	63	61	59	57	55	53
69	97	95	93	90	88	86	83	81	79	77	74	72	70	68	66	64	61	59	57	55	53
70	98	95	93	90	88	86	83	81	79	77	75	72	70	68	66	64	62	60	58	56	54
71	98	95	93	90	88	86	84	82	79	77	75	73	71	69	67	64	62	60	58	56	54
72	98	95	93	91	89	86	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55
73	98	95	93	91	89	86	84	82	80	78	76	73	71	69	67	65	63	61	60	58	56
74	98	95	93	91	89	86	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56
75	98	96	93	91	89	87	84	82	80	78	76	74	72	70	68	66	64	63	61	59	57
76	98	96	93	91	89	87	85	83	80	78	76	74	72	70	69	67	65	63	61	59	57
77	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	61	60	58
78	98	96	94	91	89	87	85	83	81	79	77	75	73	71	69	67	66	64	62	60	58
79	98	96	94	91	89	87	85	83	81	79	77	75	73	71	70	68	66	64	62	60	59
80	98	96	94	91	89	87	85	83	81	79	77	76	74	72	70	68	66	64	63	61	59

TABLE B — *Continued*

Relative Humidity, Per Cent — Fahrenheit Temperatures

Pressure = 29.0 inches

Air Temp. t	Depression of Wet-bulb Thermometer $(t-t')$																				
	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0
60	44	42	40	37	35	33	31	29	27	25	22	20	18	16	14	12	10	8	6	4	2
61	45	43	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4
62	46	44	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	8	6
63	47	45	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	13	11	9	7
64	48	45	43	41	39	37	35	33	31	29	27	25	23	22	20	18	16	14	12	11	9
65	48	46	44	42	40	38	36	34	32	30	28	26	25	23	21	19	17	15	13	12	10
66	49	47	45	43	41	39	37	35	33	31	29	27	26	24	22	20	18	17	15	13	11
67	50	48	46	44	42	40	38	36	34	32	30	29	27	25	23	21	20	18	16	15	13
68	51	49	47	45	43	41	39	37	35	33	31	30	28	26	24	23	21	19	17	16	14
69	51	49	47	45	44	42	40	38	36	34	32	31	29	27	25	24	22	20	19	17	15
70	52	50	48	46	44	42	40	39	37	35	33	32	30	28	26	25	23	21	20	18	17
71	53	51	49	47	45	43	41	39	38	36	34	32	31	29	27	26	24	22	21	19	18
72	53	51	49	48	46	44	42	40	39	37	35	33	32	30	28	27	25	23	22	20	19
73	54	52	50	48	46	45	43	41	40	38	36	34	33	31	29	28	26	24	23	21	20
74	54	53	51	49	47	45	44	42	40	39	37	35	34	32	30	29	27	25	24	22	21
75	55	53	51	50	48	46	44	43	41	39	38	36	34	33	31	30	28	26	25	23	22
76	55	54	52	50	48	47	45	43	42	40	38	37	35	34	32	30	29	27	26	24	23
77	56	54	52	51	49	47	46	44	42	41	39	37	36	34	33	31	30	28	27	25	24
78	57	55	53	51	50	48	46	45	43	41	40	38	37	35	34	32	31	29	28	26	25
79	57	55	54	52	50	49	47	45	44	42	41	39	37	36	34	33	31	30	29	27	26
80	57	56	54	52	51	49	47	46	44	43	41	40	38	37	35	34	32	31	29	28	27

TABLE C

Relative Humidity, Per Cent — Fahrenheit Temperatures

Pressure = 30.0 inches

Air Temp. t	Depression of Wet-bulb Thermometer $(t - t')$																				
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
60	97	94	91	89	86	83	81	78	75	73	70	68	65	63	60	58	55	53	50	48	46
61	97	94	92	89	86	84	81	78	76	73	71	68	65	63	61	58	56	54	51	49	47
62	97	94	92	89	86	84	81	79	76	74	71	69	66	64	61	59	57	54	52	50	47
63	97	95	92	89	87	84	82	79	77	74	71	69	67	64	62	60	57	55	53	50	48
64	97	95	92	90	87	84	82	79	77	74	72	70	67	65	63	60	58	56	53	51	49
65	97	95	92	90	87	85	82	80	77	75	72	70	68	66	63	61	59	56	54	52	50
66	97	95	92	90	87	85	82	80	78	75	73	71	68	66	64	61	59	57	55	53	51
67	97	95	92	90	87	85	83	80	78	75	73	71	69	66	64	62	60	58	56	53	51
68	97	95	92	90	88	85	83	80	78	76	74	71	69	67	65	62	60	58	56	54	52
69	97	95	93	90	88	85	83	81	79	76	74	72	70	67	65	63	61	59	57	55	53
70	98	95	93	90	88	86	83	81	79	77	74	72	70	68	66	64	61	59	57	55	53
71	98	95	93	90	88	86	84	81	79	77	75	72	70	68	66	64	62	60	58	56	54
72	98	95	93	91	88	86	84	82	79	77	75	73	71	69	67	65	63	61	59	57	55
73	98	95	93	91	88	86	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55
74	98	95	93	91	89	86	84	82	80	78	76	74	71	69	67	65	63	61	60	58	56
75	98	96	93	91	89	56	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56
76	98	96	93	91	89	87	84	82	80	78	76	74	72	70	68	66	64	62	61	59	57
77	98	96	93	91	89	87	85	83	81	79	77	74	72	71	69	67	65	63	61	59	57
78	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	62	60	58
79	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	68	66	64	62	60	58
80	98	96	94	91	89	87	85	83	81	79	77	75	74	72	70	68	66	64	62	61	59

TABLE C — *Continued*

Relative Humidity, Per Cent — Fahrenheit Temperatures

Pressure = 30.0 inches

Air Temp. t	Depression of Wet-bulb Thermometer $(t-t')$																				
	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0
60	43	41	39	37	34	32	30	28	26	23	21	19	17	15	13	11	9	7	5	3	1
61	44	42	40	38	35	33	31	29	27	25	22	20	18	16	14	12	10	8	7	5	3
62	45	43	41	39	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4
63	46	44	42	40	37	35	33	31	29	27	25	23	21	19	17	15	13	11	10	8	6
64	47	45	43	41	38	36	34	32	30	28	26	24	22	20	18	17	15	13	11	9	7
65	48	46	44	41	39	37	35	33	31	29	27	25	24	22	20	18	16	14	12	11	9
66	48	46	44	42	40	38	36	34	32	30	29	27	25	23	21	19	17	16	14	12	10
67	49	47	45	43	41	39	37	35	33	31	30	28	26	24	22	20	19	17	15	13	12
68	50	48	46	44	42	40	38	36	34	32	31	29	27	25	23	21	20	18	16	15	13
69	51	49	47	45	43	41	39	37	35	33	32	30	28	26	24	23	21	19	18	16	14
70	51	49	48	46	44	42	40	38	36	34	33	31	29	27	25	24	22	20	19	17	1
71	52	50	48	46	45	43	41	39	37	35	33	32	30	28	27	25	23	22	20	18	1
72	53	51	49	47	45	43	42	40	38	36	34	33	31	29	28	26	24	23	21	19	18
73	53	51	50	48	46	44	42	40	39	37	35	34	32	30	29	27	25	24	22	20	19
74	54	52	50	48	47	45	43	41	39	38	36	34	33	31	29	28	26	25	23	21	20
75	54	53	51	49	47	45	44	42	40	39	37	35	34	32	30	29	27	26	24	23	21
76	55	53	51	50	48	46	44	43	41	39	38	36	34	33	31	30	28	27	25	24	22
77	56	54	52	50	48	47	45	43	42	40	39	37	35	34	32	31	29	28	26	25	23
78	56	54	53	51	49	47	46	44	43	41	39	38	36	[illegible]	33	31	30	28	27	25	24
79	57	55	53	51	50	48	46	45	43	42	40	38	37	35	34	32	31	29	28	26	25
80	57	55	54	52	50	49	47	45	44	42	41	39	38	36	35	33	32	30	29	27	[illegible]

P

Methods of introducing Moisture into the Air of Schoolrooms. — In trying to control automatically the amount of moisture in the room, the Boston Commission used "periorated pipes to blow steam directly into the air," which by means of a fan was being driven over steam coils into the school-

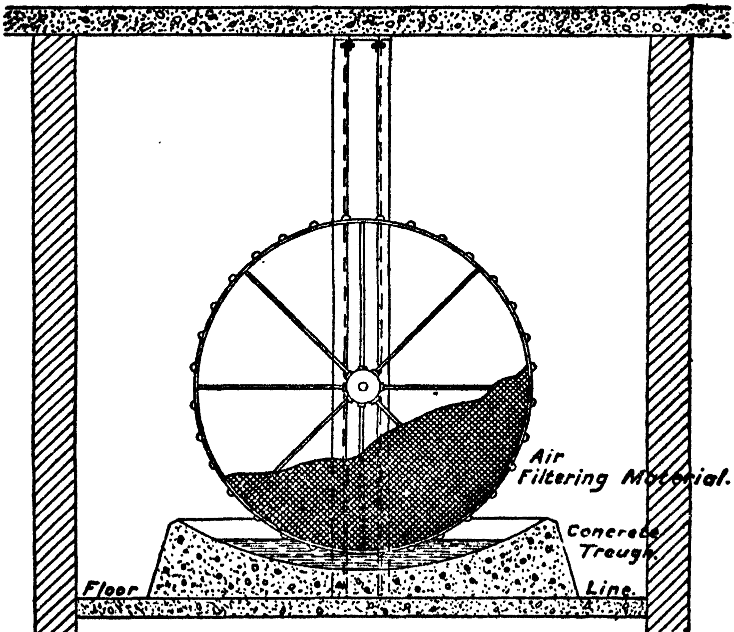


FIG. 39. — End view. A simple device for washing and humidifying the air. (See description in the text.)

rooms. This air, when entering the schoolroom, registered 67 degrees Fahrenheit. Auxiliary coils were used in the room to maintain the required temperature. By the use of a humidostat in the schoolroom set to control the flow of steam into the air, and "a recording hygrodeik to record the percentage of moisture in the rooms," the commission found that to some degree the experiment was successful, but many irregularities

were noticed. They concluded that the apparatus used required too much attention. They also speak of two difficulties arising from the use of a steam jet as a means of moistening the air: —

1. "So much steam taken from the boiler requires constant care to see that the water line does not get down to the danger point."

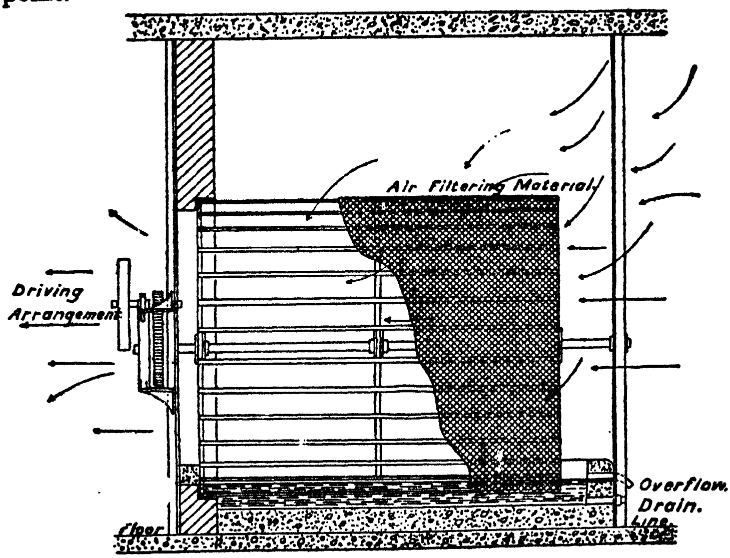


FIG. 40. — Side view.

2. "There was complaint of bad odor in the rooms, and this was due to the sediment and dirty water in the boilers."

The next method to which I wish to call attention provides for cleansing or filtering the air and also for introducing into it additional aqueous vapor. It is a modified form of an arrangement in use in a large Board school in London. The accompanying figures will help to make its construction clear. It consists, as will be seen, of a large cylinder constructed of a light framework of steel centered on a shaft with gearing

attachments at one end. Underneath it is placed a trough made of cement lined with metal, into which the wheel or cylinder will dip as it turns about the fixed shaft. Around the framework of the cylinder is bound a very loosely woven coarse cloth or mesh. This mesh covers the whole of the wheel save the inner end, which is designed to fit as closely as possible, without binding, into the opening next to the fan. The trough is partly filled with water into which the cylinder with its covering of mesh dips as it is slowly turned. There is an outflow pipe from the trough, and the supply of water in the form of a small spray strikes the mesh near the center of the outer end, thus making it sure that the end is kept wet and that the water is being constantly freshened and replenished. The cylinder can be geared to the fan or directly to the motor used for driving the fan. It ought to run slowly, making one revolution in from three to ten seconds, depending on its size. It ought not to splash the water or to throw it off by centrifugal force. The outflow should be on the opposite end of the trough from the supply jet. Through a mistake of the draftsman the overflow drain is shown in the cut at the same end as the spray. By putting this outflow at the opposite end, the water will be constantly purified as well as renewed. The amount of water thrown on to the end of the cylinder may be easily regulated by a cock in the pipe, and the form of the nozzle may be made to throw the water in such a way as not to splash, perhaps in the form of a coarse spray that would not only keep the end mesh thoroughly wet, but would drive a mist into the interior of the cylinder. A word of caution ought to be given with reference to the covering of the cylinder. It must be, as suggested, a coarse, loosely woven mesh, in order not to offer too much friction to the air as it is drawn in by the fan; and yet it ought to be sufficiently close to gather up the water and stream it down through the inside as the cylinder revolves. The one that I saw in use was covered with a coarse hempen cloth not unlike the material used for the

outer covering of a coffee bag. The meshes were large enough to take a small lead pencil. The size of the cylinder may easily be regulated to suit the demands. The cut was reproduced from one eight feet in diameter and eight and one half feet long. This readily permitted the entrance of enough air to supply a twenty-room building. The rate at which it is driven can easily be adjusted by the size of the pulleys and the gearings. It can be placed in the fresh-air duct leading to the fan, will not be in the way, and will need very little or no attention if properly made and regulated. As the cut indicates, the incoming air always strikes the wet covering at an angle, is drawn through the streaming water into the fan, and is then driven over the heating surfaces. In very cold weather or, for that matter, at any time when the amount of moisture in a cubic foot is at the saturation point, there, of course, is no evaporation as the air passes through, unless the water into which the cylinder dips is kept hot. This may be done by heating the water in the supply pipe, by a gas jet, or by immersing in the bottom of the trough some steam or hot water pipes. If this water is kept hot, the air is warmed and expanded as it enters the covering, and hence a greater percentage of moisture will find lodgment in it. If on mild days no extra moisture is needed, the heat from the trough and supply pipe may be cut off. It seems altogether possible that by regulating the size of the wheel, the size of the mesh, the rate of the cylinder, and the temperature of the water, the required amount of vapor can be thrown into the air with a minimum cost, and without the need of expert service or waste of time on the part of the caretaker. There would be no loss accruing due to the heat required for warming the water in the trough, for this would temper the air and reduce by that much the amount of heat needed to bring the air to the required temperature for the schoolrooms. Of course, in extremely cold weather, fresh air entering must be tempered before striking the cylinder, or else the water would be frozen.

Tempering coils should be located in the path of the incoming current between the cylinder and the outer air. By the use of this arrangement not only may the amount of moisture be increased, but the particles of floating dust and soot with their loads of clinging germs may be filtered and washed out so that the air will enter the rooms almost free from dust. I was told

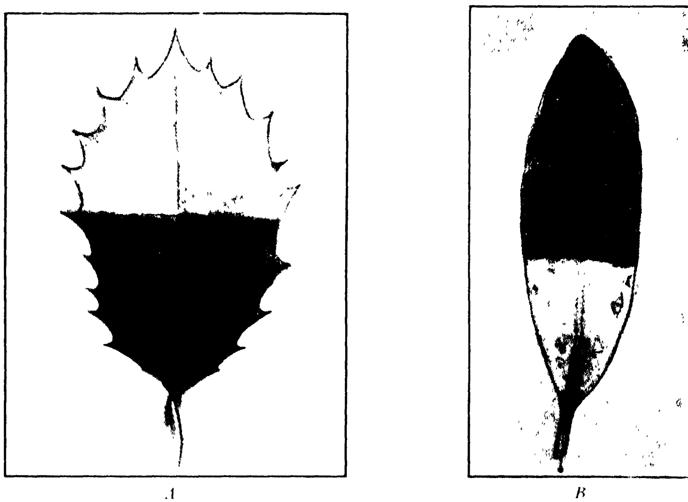


FIG. 41. *A* and *B*.—Photographs of leaves showing deposit of soot; half removed. From *The Air of Towns*, by Dr. J. B. Cohen. By the courtesy of the Smithsonian Institution, Washington, D.C.

by the headmaster and the caretaker of the Board school referred to above that on foggy, sooty days, common in London, the water in the trough, unless rapidly changed, became almost as black as ink. I examined the rooms carefully and must say they were unusually free from dust, soot, or the flotsam and jetsam of the outer air. There can be no doubt that when properly installed, this method will insure clean air. In fact, the air will lose some of its carbon dioxide as well as its dirt as it passes through the water, and will therefore enter the schoolroom somewhat fortified against the impurities there poured

into it. By tests made at this school during fogs, it was found that the air in the rooms was much safer and purer than that on the outside. It would be beyond my purpose, in describing this apparatus and its use, to make exaggerated claims about it; but I am persuaded that the principles employed, its simplicity of construction and operation, together with its known and theoretical efficiency, ought to lead those interested in furnishing pure and wholesome air to schoolrooms to give it a thorough test. It is capable of so much adaptation that I feel sure that it will not disappoint. Let me repeat again, there can be no doubt about its efficiency as a means of filtering the air. For this purpose it is certainly the best device that I have seen. It will cost very little to make, and practically nothing to operate.

The Buffalo Forge Company has recently put upon the market an air-washing and humidifying apparatus from the use of which they claim excellent results may be obtained. The essentials of this systems are a battery of spraying nozzles so constructed that the water driven through them by a force pump will emerge in a finely divided mist. These are placed in due proportion and in proper position across the intake duct for fresh air. The spray from the nozzles is driven in the opposite direction to the flow of air. The water thrown through these nozzles is heated to a temperature at which a complete saturation will supply a sufficient percentage of humidity to the air after it has passed over the heating surfaces and enters the room. For example, if the temperature in the humidifying chamber is kept at forty-eight degrees Fahrenheit, and the humidity there reaches saturation, there will be enough moisture to establish about a fifty per cent saturation in the schoolroom with the temperature sixty-eight degrees Fahrenheit. It has been claimed by W. A. Rowe, the engineer for the company, that excessive condensation on windows can be obviated by maintaining a temperature in the spray chamber never higher than a mean between the temperature of the external air and that of the

room. He claims that "this is true because the glass itself is at a temperature midway between that of the air outside and that of the air in the room, and therefore would be unable to lower the temperature of the air to its dew point." [1]

By a series of somewhat complicated eliminators this air, carrying a saturation of aqueous vapor, is washed and, it is claimed, all dust and dirt is taken out. It then passes through the fan to the heating surfaces and to the rooms. I have not seen this method in operation, and cannot estimate its efficiency. But it is evidently too complicated and expensive for small or medium-sized schools, and would either necessitate the use of a force pump or a very heavy water pressure to break up the water into a mist and to drive it into the humidifying chamber. In practice, I have found that nozzles such as are used in this method are likely to clog, especially if the water supplied is not clean.

Quite recently the Johnson Service Company has also developed a method of humidifying the air, and through a humidostat connected with compressed air, of controlling automatically the percentage of saturation in cold weather. They claim for this device a high degree of perfection with simplicity of operation. Their system may be briefly described as follows. An instrument called the humidostat is placed in the room and connected with compressed air in a manner similar to that of the thermostat. This instrument registers the amount of moisture in the air in the schoolroom, and may be set in connection with their humidifier to keep the moisture at the point of saturation required. The humidifier, according to their plan, is described as follows: "The moisture or humidifier may be one of several forms. Where steam heating is in use, and the steam is clean and odorless and free from oil from engines, a perforated pipe or pipes in the air duct is the most simple and perfect humidifier. The outlets are properly adjusted, and then the humidostat shuts off and lets on the steam

[1] See *Engineering News*, Vol. 60, No. 7, p. 171.

as required. Sometimes a water spray, particularly of warm water, may be used in place of steam. Where neither steam jet nor water spray is advisable, an evaporating spray is the most perfect arrangement." In the plan above mentioned a steam coil immersed in the water is used to keep it at the evaporating point, and the humidostat is set to regulate the flow of steam through this coil, and thus indirectly to vary the amount of moisture thrown into the air as it passes over it on its way to the room in question. The amount of water in the pan is regulated by a common float and its connecting valves. I have not seen this method in use and hence cannot speak of its effectiveness. It is plain, however, that it makes no provision for filtering the air, and that if steam is used, the difficulties that the Boston committee found would present themselves. Also special provision would have to be made in the air ducts for pans or pipes, for unless this were done, much friction would reduce the rate of the air current and so hinder the amount of air supply in the schoolroom, which would bring more trouble than it would give relief. The principles upon which their humidostat depends for effectiveness are not explained in their literature which I have seen. The claim is made that, with this method, the moisture may be automatically regulated *within two per cent* of that required. If this can be done within reasonable limits of expense and supervision, this system will merit approval. But it will be a safe thing for schoolmen with reference to all humidifiers on the market to contract for them on conditions definitely stated and then to make sure that they are properly tested before accepted. The sling psychrometer already described and the tables given will furnish the means of testing accurately at little or no cost.

Another and very promising method of washing, humidifying, and cooling the air where a plenum system is used for ventilation is that manufactured by J. Zellweger & Son, St. Louis. As will be seen by referring to Fig. 42, water is thrown

directly into the fan by a series of fine sprays. Here it is broken up into a fine mist by specially arranged series of wires, and this washes the air.

It is used in several of the best buildings of St. Louis, where I had the chance to examine it.

The advantages claimed for it are its simplicity, its saving of space, and its ready adjustment. It will be obvious to any

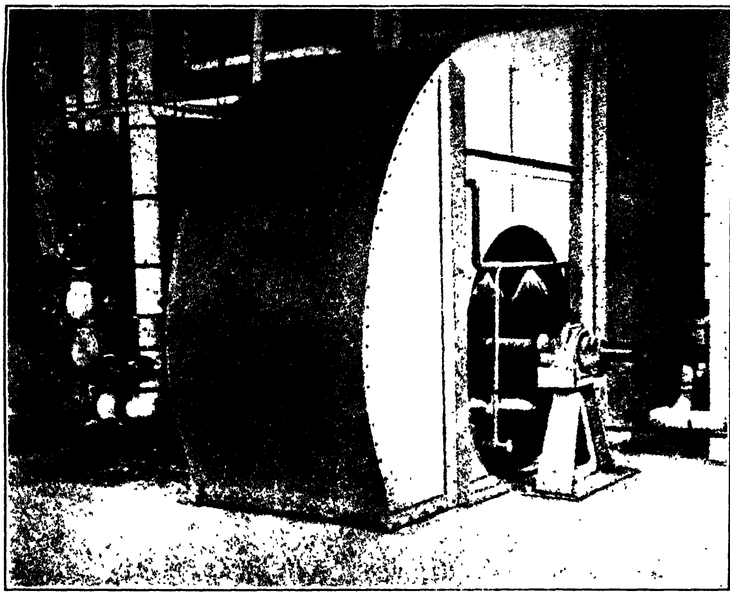


FIG. 42. — Zellweger air washing and cooling fan.

one, however, that a fan so conditioned will not deliver as much air, other things being equal, as one of the same size without the impediments thus introduced. Thus a larger fan of this type will be required, but it will clean and moisten the air at very little expense and, apparently, with very little supervision.

Humidity and Comfort. — Within certain physiological limits we are comfortable in an increasing temperature if at

the same time there is a decrease in the amount of moisture. For example, a temperature of seventy-eight degrees Fahrenheit with thirty-five per cent of saturation is about as comfortable as sixty-eight degrees Fahrenheit with fifty-eight per cent saturation. Dr. Richards states that the most comfortable air condition for indoor workers, as far as temperature and humidity are concerned, is that from sixty-four degrees Fahrenheit, with a humidity of sixty per cent saturation, to that of sixty-eight degrees Fahrenheit, with a humidity measured by forty per cent saturation.[1] While this estimate seems to be safe and fair, it does not attempt to say that this could apply to all cases alike. There are so many individual differences and idiosyncrasies to deal with that one despairs of giving general advice. Besides, the term "indoor workers" must be applied to sedentary employment, rather than to active indoor workers. It is a fair general estimate, however, to apply to schools when the buildings and other conditions are normal.

TOPICS FOR INVESTIGATION

1. Why are cold, rainy days so chilling?
2. Why are warm, rainy days so uncomfortable?
3. Since human life through its long evolution is naturally adapted to out-of-door conditions, would it not, therefore, be advisable to keep the air in a schoolroom as moist as that out of doors?
4. Why are coughs, colds, influenza, and other diseases of the throat and respiratory tract more prevalent in winter than in summer?
5. Determine whether or not in a cold climate, such as prevails in the northern and northwestern part of our country, the saving in fuel would amount to the sum required to furnish the proper humidity.
6. Note how quickly the water evaporates from a saturated cloth in the air of a schoolroom on cold days. How is this on warm, moist days?

[1] See *Conservation by Sanitation*, p. 8 (chart), by Ellen H. Richards. John Wiley & Sons, 1911.

SELECTED REFERENCES

CARRIER, W. H. *Air-conditioning Apparatus.* Journal Amer. Society of Mechanical Engineers, v. 33, pp. 1613–1688, December, 1911.

Report of Committee on Air Washers. Transactions Amer. Soc. of Heating and Ventilating Engineers, 1912, v. 16, pp. 136–143.

PRUDDEN, T. M. *Dust and its Dangers.* New York, 1910. 113 pp.

TYNDALL, JOHN. *Essays on the Floating Matter of the Air, in its Relation to Putrefaction and Infection.* New York, 1902. 338 pp., illus.

WILSON, G. B. *Air Conditioning.* New York, 1908. 143 pp., illus.

CHAPTER XV

EYE DEFECTS AND SCHOOL CONDITIONS

School Work is often Harmful to Children's Eyes. — There can be no doubt of the fact that there is danger of our children injuring their eyes under the pressure of modern school demands. In fact, the results of careful examinations made in all progressive countries prove conclusively that school conditions are responsible for a large part of the nearsightedness prevalent among the children of the higher grades. It has been determined by many different investigations that myopia (nearsightedness) is not often, if ever, inherited, and is rarely congenital. It is known, however, that anatomical predispositions toward this difficulty, and perhaps physiological ones, are inherited. That is to say, some children do inherit from their parents conditions that are favorable to the development of myopia, and such children need more careful attention in school, otherwise they soon suffer as a result of the work imposed. Myopia usually develops during the early years of school age as a result of school requirements or other work that makes it necessary for the children to bring the objects with which they work too close to their eyes. This overburdening is not to be wondered at when we stop to investigate the causes. Children are required to use books much more freely and continuously now than they were under former conditions; school terms are longer, and the curricula are fuller. Moreover, the amount of written work demanded of pupils is increasing. Under these conditions, unless teachers are especially careful, many children are compelled to overburden their eyes, and because of this, permanent visual difficulties are brought on.

In order to understand the necessity of great care on the part of teachers, it will be well to pass in review some of the facts of the physiology of vision and those defects that develop as the result of using the eyes habitually under unfavorable conditions.

Shape of the Eyeball and its Effect on Vision. — A normal eye is so shaped that the rays of light, reflected from the object of vision properly placed, come to a focus exactly on the retina.

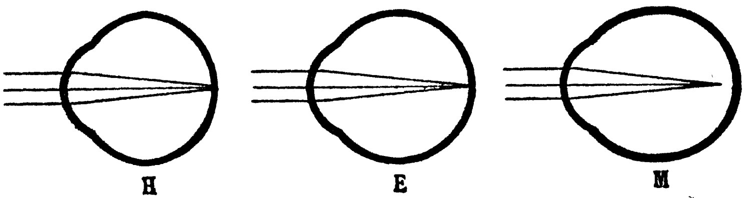


FIG. 43. — *H*, hypermetropia; *E*, emmetropia; *M*, myopia.

Such an eye is called an emmetropic eye, that is, one properly formed. But if the eyeball is too short from the front to the back, the rays of light entering it will not reach a focus by the time they impinge on the retina, and will be spread out on it in a sort of diffused way. The result of such a condition will, of course, be indistinct and blurred vision. The same external point reflecting the light would tend to stimulate the retina in a number of adjacent places, instead of at a single point. If, for example, a person whose eyes are defective in this way were to look at the letter T, he would see something like the following instead of a clear and distinct image.[1] (Fig. 44.)

This condition of the eye is termed hypermetropia, and an eye so shaped is called an hypermetropic eye; that is, too short from the cornea to the retina. It is very common for those who speak of defective eyesight in school children to confine their discussions almost wholly to myopia and astigmatism. True, these are common defects, and without doubt defects

[1] See Roosa's *Defective Eyesight*, p. 120, Fig. 23.

prolific of disturbances to health and the normal progress of the learners, especially of the children of the upper grades. But it ought to be remembered that most young children are hypermetropic and see clearly neither near nor far objects without accommodation. If the eye of the child is permitted to develop normally, it will increase in length until its anterior-posterior diameter exactly corresponds to the refracting media and the child can then see the far points of vision clearly without any effort of accommodation. In other words, he has

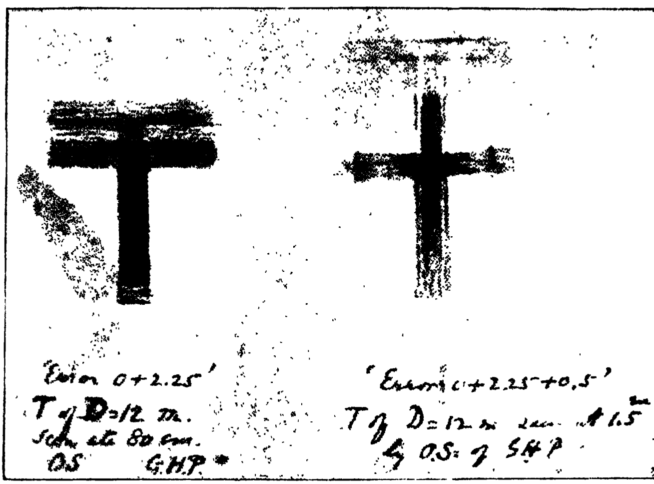


Fig. 44.—From Roosa's *Defective Eyesight.*

become an emmetrope, or has normal vision. He sees things at a distance clearly and has power to accommodate for near vision. But if, during the hypermetropic stage, his eyes have been overtaxed, serious difficulties may arise.

Hypermetropia.—When, therefore, hypermetropia exists to a marked degree, that is, when the eyeball is too short for the refracting media to bring the rays of light reflected from a given point to a focus on the retina, nothing in the field of vision can be seen distinctly unless strong and continuous

effort is made to accommodate the eye, and this continuous effort will cause much disturbance. The child suffering in this way is more seriously handicapped as regards the effort to accommodate than the myopic child, since he must depend on accommodation to see either near or far objects clearly, for, without this effort, nothing is properly focused on the retina; while the myopic child needs no accommodation for near objects and cannot accommodate for distant vision. In discussing this point, Fuchs says:

"While the hypermetrope needs accommodation even for distant vision, this is much more the case for seeing near by. Let us assume that work has to be done at a distance of thirty-three centimeters. For this purpose the emmetrope must use an accommodation of 3 D. A hypermetrope with hypermetropia = 2 D also uses the same amount of accommodation; but he must employ 2 D more to conceal (overcome) his hypermetropia, so that altogether he must make an accommodative effort of 5 D. Now as his range of accommodation is no greater than that of an emmetrope, this great amount of accommodation causes him more trouble in proportion. He may be said to be always dragging about with him a deficit in his accommodation, a deficit which causes him to become exhausted quickly when doing near work. At first, vision near by is distinct and the work goes on well; but after a little while, the object, print, near work, and so forth, begin to grow indistinct and are blurred as though enveloped in a slight haze. This is owing to the fact that the overstrained accommodation gives way, and the eye then ceases to be properly focused. A short period of rest, during which the eyes look at distant objects or are kept closed, enables them to continue the work. But the same obscuration soon sets in again and compels another pause. These periods of enforced rest are the more frequently repeated and are of greater duration the longer the work is kept up. With them are associated pains in the eyes, and more especially pains in the forehead and headaches." [1]

Furthermore, it will be seen that a child may be able to conceal for a time a high degree of farsightedness simply by his power to accommodate, so that even a test card will not reveal it; for by dint of effort he can focus on the letters so as to see them clearly. For this very reason the condition of many

[1] See Fuchs' *Textbook of Ophtholmology*, p. 645.

children in school is misunderstood. They see clearly, but have to make a serious sacrifice in eyestrain to see clearly and to do the amount of near work required of them, and in time they will inevitably have to pay the penalty.

Myopia. — When, however, for various reasons, the eyeball becomes elongated so that the focal distance is too great, and the various rays of light entering the eye from any given point are focused before they reach the retina, we have a condition of myopia, or what is commonly called nearsightedness. It is evident that here, as in the former condition, it is impossible for such an eye to furnish to the brain a clearly marked and well-defined stimulus, coming from a distant object, from which satisfactory sense perception may result. For the rays would cross and spread out more or less on the retina, rendering the image imperfect and hazy in its definition. This inability to see distant objects clearly is a constant and persistent cause of fatigue, which tends to exaggerate the difficulty, as we shall see more clearly farther on.

"This defect," says Howell, "may be due to an abnormally great curvature of the refractive surfaces, the cornea or the lens, or to an abnormal length of the eyeball in its anterior-posterior diameter. The last cause is the most common. The defect may be congenital, but usually it is acquired, and in the latter case its cause is generally attributed to a weakness in the coats of the eyeball. The interior of the eye is under some pressure, intraocular tension, which is estimated to be equal to the pressure of a column of mercury 25 to 30 mm. in height. This tension is increased by strong convergence of the eyeballs in looking at near objects. If the coats of the eye are weak or become so from disease or malnutrition, they may yield somewhat to this pressure and the eyeball become lengthened in the anterior-posterior diameter. . . . Much of the prevalent myopia in the young is attributed by oculists to bad methods of reading, such as insufficient lighting, small print, and faulty position of the book. Such conditions lead to an excessive muscular effort and thus aggravate any tendency that exists toward the development of a nearsighted condition."[1]

[1] See Howell's *Textbook of Physiology*, pp. 295 f.

Mental Effect of Myopia.—At this point let us stop to consider what it really means for a child to acquire a high degree of myopia. Unless corrected by glasses, his horizon is limited and he sees nothing clearly unless it is within his immediate reach. The trees are mere blurs, and the leaves have no definite form. The fields fade into shadowy ghosts of their own inviting reality, and the hills are lost in a sort of mental fog. Indeed, the whole world of clearly visible things must be constructed out of small pieces of experience coming within the narrow circle of what he may focus on a retina adjusted to a distance within reach of his faulty vision. He cannot stand on the hilltop and, with a swift glance, bring the valleys and rivers clearly and distinctly before his mind's eye. There is none of that largeness and distinctness of imagery that make for expansion of soul and clearness of expression. I shall never forget the raptures of delight evoked by the first real vision of trees and birds, when a little girl whose eyes were out of focus was fitted with glasses. "Are these trees?" she exclaimed. "And are those beautiful things the leaves? Can the birds rest on those tiny branches away up in the top? Oh! how beautiful the world is! I never saw it before to-day." This is a true story and is only one of many that every observant student of child life could recount. Myopia is a physical defect that often produces "mental near-sightedness" and to a greater or less degree mental starvation. There is a tendency for the person so afflicted to resort to introspection, to rely on distortions of the real world outside, and hence to dwell on abstractions or fancies out of harmony with the objective world. Such a tendency, begun too soon, will warp the emotional life and usually results in curbing normal emotional development.

Those children who are afflicted with a high degree of myopia and are not properly fitted with glasses are inclined to sedentary life, for the whole world, except a few feet from them, is hazy and uninviting. They cannot play ball with any degree of

accuracy, for the ball is indistinct until almost within their reach. They cannot coöperate in any large and effective way with their fellows on the playground, because they cannot understand signals easily. They cannot see opportunities for the fine points in the game, and consequently are left out as incapables. They cannot play tennis or hocky with certainty without glasses, and with them they are endangered through flying balls, sticks, or stones. Unless their vision is corrected by glasses, everything tends to drive them to books or pictures, or at least limits the expenditure of their energy in both play and work to things or conditions near at hand. This condition, to a marked degree, is a real inversion of child life, for children are first in need of exploring fields and woods, becoming acquainted with a larger and larger environment. It is only in later years that they need to examine, in detail, the recorded experience of others. By the time children reach six years of age they have gained some power over their muscles and are filled with the desire to use them. They like to run about and delight in those games that make demands on muscle rather than on eye and ear.

Civilization and Myopia. — Shortsightedness is a defect mainly developed by the demands of the sort of civilized life that we are leading. Kotelmann says myopia is never found among savage tribes, and cites the results of his own investigations in proof of this statement. Whether this sweeping conclusion is wholly true or only partially true, there have been so many investigations made in recent years touching visual defects in school children that we now know beyond the shadow of a doubt that myopia becomes a much more common defect with children as the length of their time spent in school increases. Furthermore, not only does the number of children so afflicted progressively increase in the upper grades, but when the vision is uncorrected by glasses, the eyeball often becomes elongated and tends to further divergence from its normal form by reason of the added strain and

congestion brought on by school work when performed under such conditions. Hence there is a progressive increase in such defects. These investigations have also shown that in Germany, where the German type is used, myopia is possibly more frequent, other things being equal, than in those countries that use the Latin letters; for it is claimed that the former are less easily distinguished, demand closer observation, and consequently produce more eyestrain.

Results of Tests of School Children. — From tests to determine the acuity of vision made on four thousand seven hundred and sixty-five pupils in the elementary and high schools of Chicago, in 1900, Mr. Smedley, the Director for Child Study, found that "thirty-five per cent of all the pupils tested were defective; thirty-seven per cent of the girls and thirty-two per cent of the boys. Thirty-two per cent of the six-year-old pupils were found subnormal in vision. For the first three years of school life the percentage of those defective rapidly increases, suggesting that the school work of that period is hard on the eyes of the pupils. After the age of nine years is passed, the percentage of pupils having eye defects decreases; at first slowly, then more rapidly until the age of thirteen is past." Dr. Smedley suggests that the decrease in the percentage of defectives between the ages of nine and thirteen could be accounted for on the basis of the improved health incident to this period of rapid growth. While this statement is reasonable and partly justifiable, it seems to me that it is probable that one reason for this decrease can be found in the fact that a larger percentage of defective children drop out before this period is reached than those who were found with normal acuity of vision. It is very likely, too, that many of those who showed defects in acuity at six years of age were hypermetropic and later through their attempts to adjust their eyes prematurely to book work, would pass through the emmetropic condition and later pass on into a permanent stage of myopia.

Besides, it will be seen from a study of the figures given in his table that in general the seriousness of the defects increases with the age of the children. His table follows: —

School Life and Sight

Age	Number Tested	20/30 and Below	20/40 and Below	20/50 and Below	20/70 and Below	20/200 and Below
6	264	32	7	4	1	0
7	363	35	8	4	2	1
8	351	38	13	9	3	1
9	343	44	17	11	6	1
10	364	43	18	13	9	2
11	385	41	17	13	8	2
12	364	36	16	14	9	2
13	373	30	14	13	9	2
14	450	32	14	13	9	3
15	521	32	15	13	9	3
16	475	32	16	13	11	4
17	399	32	16	14	12	4
18	173	32	16	13	10	8

Since the examinations upon which these figures are based were made, hundreds of other tests have been made, and they all show in general the same results.

The following table gives the summaries of the results of examinations made on Japanese schoolboys attending special and higher institutions during the years indicated. It is taken from the Thirty-fifth Annual Report of the Minister of State for Education, published in English at Tokyo, 1910.

It is a matter of common observation that those who are afflicted with myopia can see things clearly near by, and to a certain degree have an advantage over those with normal vision, for they need no accommodation, and hence are relieved from some of the effort that normal eyes must make to focus near-by objects.

"The *troubles* that myopes complain of," says Fuchs, "vary according to the degree of myopia. In the lower grades of myopia distant vision is indistinct, and yet often suffices for

TABLE D

TABLE SHOWING THE PERCENTAGE OF MALE STUDENTS OR PUPILS EXAMINED IN RESPECT OF PHYSICAL CONSTITUTION AND EYESIGHT IN THE SCHOOLS UNDER THE CONTROL OF THE DEPARTMENT OF EDUCATION

	Number of Students or Pupils Examined	Physical Strength			Eyesight						
		Strong	Medium	Weak	Both Eyes	Left Eye			Right Eye		
					Normal	Normal	Long-sighted	Short-sighted	Normal	Long-sighted	Short-sighted
1907–8	17,053	53.0	45.2	1.8	61.5	2.3	0.9	34.8	2.2	0.9	35.0
1906–7	15,483	54.3	43.1	2.5	60.9	2.1	0.9	35.5	1.9	0.9	35.7
1905–6	14,600	56.2	42.1	1.7	61.5	2.5	0.3	35.0	2.3	0.2	35.3
1904–5	13,870	51.9	46.0	2.1	63.9	2.1	0.2	33.5	1.8	0.1	33.9
1903–4	12,784	53.5	43.5	3.0	64.2	1.9	0.1	33.6	1.5	0.2	33.9
1902–3	10,917	47.0	48.8	4.2	63.0	2.6	0.3	33.9	2.0	0.2	34.5
1901–2	9,823	43.4	50.9	5.7	62.6	2.2	0.4	34.6	1.7	0.4	35.2
1900–1	8,552	48.8	48.1	3.1	61.3	1.9	0.5	36.0	1.6	0.4	36.3

ordinary purposes, so that many myopes of this sort do not use glasses. For near work, moderately nearsighted eyes are generally regarded as serviceable, because they do their work with less accommodation, and, either become presbyopic late or do not become so at all."

Eye Fatigue and Myopia. — "It is otherwise with the high degrees of myopia. In this case, not only is the complaint made of indistinct vision at a distance, but also of inability to keep on with work near by for any length of time; for owing to the short distance at which the far point lies, a considerable effort of convergence is required — an effort that, moreover, is often rendered difficult by insufficiency of the internal ocular muscles — so that troubles symptomatic of muscular asthenopia develop. From this insufficiency may develop a *strabismus divergens*, a condition most frequently met with as a result of marked myopia. In myopia of high degree, it is often the case that satisfactory distant vision is not attained even by glasses because morbid changes exist in the fundus. For the same reason, vision close by is frequently defective in spite of the close proximity of the object. Moreover, complaint is made of rapid exhaustion of the eyes, of great sensitiveness to light, and of *muscæ volitantes* (floating specks in the eye)." [1]

Astigmatism. — There is another set of eye defects that must be mentioned here, for though they are not, as a rule, the results of unhygienic school work, they are prolific of much trouble in connection with school work. We refer to the various forms of astigmatism. While in a very definite sense all such defects might be classed as variations in the length of the eyeball, just as Dr. Roosa [2] so classifies them; yet in order to make the facts clear and simple, it is best to differentiate them and to speak of them separately.

It is plain that, in order to focus rays of light entering the

[1] See Fuchs' *Textbook of Ophthalmology*, pp. 630 f.

[2] See *Defective Eyesight*, Roosa, p. 19.

eye, the cornea must be of such a shape as properly and regularly to refract these rays as they pass through it. If, however, as it often happens, the curvature of the cornea in one meridian of the eye is not the same as that in another meridian, the rays of light radiating from a point and falling upon these different meridians will not be focused at the same place on the retina. This will, of course, lead to the formation of imperfect and hazy images. For, though the eye may be properly adjusted to get a clear impression from one set of rays, it will be out of focus for others.

If a child whose eyes are markedly defective in this way be sent to school, and be required to use his eyes without proper glasses, under unfavorable conditions, or, for that matter, when he uses them much under the most favorable conditions, he will constantly suffer from eyestrain due to his persistent attempts to adjust them so as to see more clearly and rid himself of disturbing secondary images. Thus it happens that various forms of astigmatism, congenital and acquired, not only become serious hindrances to distinct vision, but also fruitful causes of eyestrain.

Astigmatism is by far the most common visual defect. Dr. Pardee[1] has found that of ten thousand eyes examined in his office, 83.5 per cent of the left and 84.8 per cent of the right were astigmatic. In commenting on these results, he says: "A fraction over 70 per cent of all the examinations were made on account of headaches being complained of by the persons examined and 41 per cent of the examinations were made on school children or persons attending higher institutions of learning."

Eyes of Country and City Children. — According to a chart reproduced by Dr. Crowley,[2] it has been shown by Dr. J. P.

[1] See *Discussion of Ten Thousand Eyes examined for Refractive Errors*, in Proceedings of Medical Society of California, Vol. 29, 1899, pp. 98 ff., by Dr. George C. Pardee, A.M., M.D.

[2] See *The Hygiene of School Life*, p. 32.

Williams-Freeman that city children, as compared with country children, show a marked deterioration of vision, both in the case of those who entered school with normal vision, and those who were defective at the beginning of their school work. Doubtless there is truth in the statement that country children are better conditioned for seeing things at a distance and profit accordingly; but it seems likely that the greater freedom in the open air, better nourishment, and more wholesome exercise all enter as contributing causes. It cannot be successfully denied, however, that the eyes of children, while capable of great accommodative power, are not as easily adjusted for near vision as for objects at a distance, and since the horizon of many city children is extremely limited, things near at hand have an undue opportunity to influence the eyes accordingly. The figures referred to make it appear that 64.5 per cent of those examined and found possessed of normal vision were country children, while of those whose capability in both eyes amounted to only two thirds of normal vision 68.5 per cent were from the city.[1]

School Conditions Required. — Turning our attention upon school conditions, we can readily see, from what has been said above, that some of the more important hygienic demands touching these things are often neglected. There are certain precautions that ought to be taken in every schoolroom and for every child in the schoolroom in order to prevent the development of such difficulties, or, if defects already exist, to minimize the evil consequences incident to the demands of ordinary school work. Among these are the following: —

Proper Light. — There must be the necessary amount and the proper kind of light in the schoolroom. If this demand be disregarded, the eyes of the children will suffer, for lack of light will, of necessity, compel the child to bring the objects that he has been directed to observe closer to his eyes, in order

[1] Author has not seen the original paper by Dr. J. P. Williams-Freeman, and no mention was made by Dr. Crowley of the number of children examined.

to see them with sufficient clearness; and if this forced accommodation is continued too long, fatigue, eyestrain, and, finally, myopia will result.

Good Type for School Books. — The child must be furnished with books properly printed on good paper. The type ought to be plain and much larger for young children than that which can be used properly in books for adults. The reason for this is sometimes not clearly understood, though the facts are recognized. Children's eyes are not so sensitive as those of adults. Or perhaps it would be better to say that children are unable to discriminate in things visible, as well as adults do. In order to see words with equal clearness and with the minimum amount of effort necessary to recognize them readily, the words for the child must be printed with larger type, and separated by greater spaces. It is surprising how little these facts are practically considered by publishers of children's books, though there seems to be, at the present time, a tendency, in some quarters at least, to do better in this regard. The author took occasion recently to examine somewhat critically a large stock of children's Christmas books with especial reference to the kind of type used and to the arrangement and spacing of the words and lines. The result was that not one in a hundred was found properly printed for children to read with ease. Many of them used type of fantastic patterns which would sorely tax the eyes of adults to read. Others used type far too small, and crowded the words together into such irregular or crooked lines that much effort was, at times, needed to follow them. In nearly all, there was a noticeable attempt at ornamentation of the page by the use of the type, and legibility seemed, at times, to be of secondary importance.

But the most trouble does not arise from the use of these books, though it would not be easy to overestimate the evil results that they produce. The chief danger comes from the daily use of school textbooks that have been printed with type two or three sizes too small, and much worn from long use.

In many instances it is impossible for the teachers to prevent this, because they are required to use the books adopted by those in authority. In all cases, however, teachers can make known to the authorities the dangers arising from the use of books improperly printed, and this will invariably help to guard the health of the children from such unnecessary and unhygienic demands. As soon as teachers are alive to the necessity of care in these things, and are able to give rational reasons why some are good and others bad, then school authorities will listen and heed their warnings. It is a pertinent question here, then, to ask, What is the proper type to use in books for school children? The following paragraphs quoted from Dr. Young's famous Report to the Maine State Board of Health[1] will explain themselves, and at the same time furnish teachers a ready means of testing the size of type suitable for children's books: —

> Books printed from type smaller than "long primer" should never be put into the hands of pupils of any grade, and those for young children should be printed from "pica" or "great primer." Full-faced Roman type is much more suitable than the "light-faced" type now so much in favor.
>
> The distance of the letters from each other should not be too slight, and the different words in the same line should stand far enough apart to enable the eye rapidly and easily to take in the picture of each. The distance of line from line should not be less than 2.5 millimeters, disregarding the longer letters, and Cohn prefers 3 millimeters ($\frac{1}{8}$ inch). When lines are of too great length, the eye has a difficulty in running back to the beginning of the next line. Some authorities state that the length of line should not exceed 100 millimeters ($3\frac{7}{8}$ inches, the same as that of this page); others, as appears to me more wisely for schoolbooks, place the limit at 80 or 90 millimeters ($3\frac{1}{8}$ or $3\frac{1}{2}$ inches).
>
> PEARL, as the printers call it, is unfit for any eyes, yet the piles of Bibles and Testaments annually printed in it tempt many eyes to self-destruction.
>
> AGATE is the type in which a boy, to the writer's knowledge, undertook to read the Bible through. His outraged eyes broke down with asthenopia before he went far and could be used but little for school work the next two years.

[1] See the Seventh Annual Report to the State Board of Health of Maine by the Secretary, Dr. A. G. Young, p. 193.

NONPAREIL is used in some papers and magazines for children, but, to spare the eyes, all such should, and do, go on the list of forbidden reading matter in those homes where the danger of such print is understood.

MINION is read by the healthy, normal young eye without appreciable difficulty, but even to the sound eye, the danger of strain is so great that all books and magazines for children printed from it should be banished from the home and school.

BREVIER is much used in newspapers, but is too small for magazines or books for young folks.

BOURGEOIS is much used in magazines, but should be used in only those school books to which a brief reference is made.

LONG PRIMER is suitable for school readers for the higher and intermediate grades, and for textbooks generally.

SMALL PICA is still a more luxurious type, used in the North American Review and the Forum.

PICA is a good type for books for small children.

GREAT PRIMER should be used for the first reading book.

If teachers would refuse to use books improperly printed or at least enter vigorous protests against their use, it would not be long until publishing companies would make their books in accordance with the laws of hygiene. While it is the use of improper type that we most frequently condemn in school books, yet occasionally we find some books in which the paper used is of such poor quality as to make the page look blurred and indistinct. This is a culpable mistake and the children suffer as a result. The paper ought to be of good quality and of a dull finish, so as to avoid all dazzling effects in reflection and to prevent the letters on one page from showing through on the other. All careful observers have noticed how often publishers, in order to reduce the initial cost of their books, have

had recourse to a cheap, unsatisfactory quality of paper, and have thereby imposed serious burdens upon their readers. But, thanks to the growing enlightenment of the teaching profession, and to a higher appreciation of child life, some of our textbooks are coming to be models of carefulness in this respect.

Writing and Vision. — Young children should not be overburdened in the matter of written work and should be taught to write a large, round, vertical hand, or at least approximately vertical. It seems that in recent years the amount of written work demanded of school children has been on the increase. This is perhaps due chiefly to the fact that in order to do the work assigned her and prepare the children for examinations and promotions, the teacher, who is expected to handle from forty to fifty children, not having time during school hours to hear all recite orally, sets many tasks in written work so that she may look over the papers later. Sometimes it goes even farther than this: children are then set to writing to keep them busy. Formerly it was a favorite mode of punishment with many teachers arbitrarily to command an offender to do "copy" work. This barbarism is now seldom perpetrated, thanks to Spencer's chapter on "Moral Education" and other vigorous protests against irrational punishment. Much writing is harmful to children, because very few of them sit erect while writing. Nearly all of them are inclined to bend over the desk and bring their eyes too close to the paper. This tendency is much aggravated by the fact that nearly all school desks are very much too flat, and in addition are badly placed.

Too Much Reading required in "Home Work." — Because of the extra demands made on the children by reason of the recent expansions of the curricula, teachers are requiring of them more and more home work. This work, too, is most often, of necessity, done in the evenings and very frequently under unfavorable conditions. It is the unusual home in

which lights, chairs, and tables are properly arranged for the use of children at study. If children are given regular tasks to perform outside of school hours, the teachers should know what difficulties are to be surmounted, and what opportunities are afforded for doing the work assigned. Otherwise there is danger of imposing upon the children.

It is not easy to overwork the eyes of healthy normal children when proper light is afforded and the objects which they are asked to observe are sufficiently large to make a clear distinct image on the retina without undue effort to accommodate. But all teachers who have taken any pains to find out the conditions under which the work assigned to be done at home is usually done know that it is unsafe to the health of the children to demand much regular eye work in the evening from those even in the higher grades of common schools.

The best artificial light is not to be compared with daylight as a satisfactory medium in which to work. But the fact which should be ever present in the mind of the exacting teacher is that the lights of the average home are far from being the best. Besides, it is often true that such lengthening of the school day may be one of the causes of the lack of spontaneity noticeable during school hours. This topic, or phase of the subject, will be spoken of more at length under the subject of fatigue.

A Tendency to demand the Use of Small Things. — The nature work, which is properly finding a large place in the curriculum, should deal with material with which children can work most satisfactorily. Their attention should be called first to the larger phases of their environment, not only because these will be more readily and more easily observed, but also because these primal facts will have a lasting influence on the further development and thought life of the individual. To limit children, then, to the study of small things which can be brought into the schoolroom, not only harms their eyes,

but also prevents them from attaining those wider views of nature that are so important as formative agents in the growth of human character.

There seems to be a tendency among teachers for the lower grades to select for observation and study those things that are likely to tax the eyes of the children unduly. This is unfortunate, as we have indicated, both from the point of view of the purpose of the work as well as the proper hygienic care of the children. Such things are selected in the main, not because teachers are predisposed toward them, but simply because they can be brought into the schoolroom. It is possible, too, that teachers unintentionally emphasize the importance of the less obvious, because these appear to them to offer better means of testing the observing power of the children. Be that as it may, we know that it is better for them to study the larger and more obvious facts of nature than the minute and microscopic. I have been struck with the fact that most college students who take courses in botany give a large part of their time in such study to microscopic work. They know much about the invisible world, but most of them do not know an elm tree from a beech, or a white oak from a linden. They have little knowledge of the character of the trees, and less about their relations to physiography, climate, and agriculture. Likewise those who study zoölogy frequently begin with the microscope and never get out into the larger world of animal life. They learn much about cells, protoplasm, etc., but many of them cannot distinguish a toad from a frog, a gar pike from a bass, or a jay bird from a robin. I have no desire to find fault with the method of teaching biology in colleges, but somewhere in the preparation of our teachers they should be brought into a vital and intimate knowledge of the larger world, else they will inevitably attempt to satisfy the children with material out of their reach and beyond their physical and mental powers to acquire. Nature study will not only fail of its purpose, but will harm the eyesight of the children if the minute and

less obvious things are presented instead of the larger, and, to them, the more important phases of life.

Weak Vision and Lack of Vitality. — Trouble with the eyes may arise not as a result of malformation of the organs themselves, but as a result of overexercise when the nervous system is suffering from lack of vitality and general neurasthenia. Several students who have worked with me of late years were suffering from this trouble. They visited many oculists to no avail, because oculists cannot reinvigorate their systems. They needed rest and nourishment in order to regain their usual vigor. Dr. Overend has called this condition ocular neurasthenia. He says: "I wish to emphasize the fact that the normal eye, under the exactions of modern life, is being heavily worked — very frequently overworked. As to this, the experience of every oculist will testify, for there is a well-recognized class of asthenopic emmetropes. In addition to this, there is a large and, perhaps, increasing class of emmetropes who are asthenopic by reason of general neurasthenic condition. These are asthenopic because they are neurasthenic. With them the eye is the organ that gives local expression to the general fault."

Effect of Sudden Contrasts. — The muscles of the iris are automatic in their movements, but rather slow. Sudden contrasts of strong light and weak illumination are painful and likewise harmful to the retina. For example, if the eye, adjusted to a dim light, is suddenly turned toward a brilliantly lighted object, the retina will receive too much light, and will be shocked before the muscles controlling the iris can react to shut out the superabundance of light. If contrasts are not strong, but frequently made, that is, if the eye is called upon to function where frequent adjustments in this way are necessary, the muscles controlling the iris become fatigued, respond more slowly and less perfectly. As a result, eyestrain in the ciliary muscles is produced and the retina is overstimulated. This is one cause of headaches and tired eyes. It is only neces-

sary to call attention to the painful results of a flickering light to bring this to the attention of all who do much work with their eyes under conditions of irregular illumination.

The Eye naturally adjusted for Distant Vision. — Throughout the life history of mankind the ability to see things clearly at some distance has played a large part in his ability to adjust himself to his environment, and hence his eyes have naturally developed to meet this demand. With little or no effort at accommodation normal full-grown eyes are ready to focus distant objects on the retina; but for those objects very close to us, especially if they are small, we are compelled to adjust and to hold in control certain fine muscles of the eyes in order to bring the rays of light reflected from the objects to a proper focus on the retina. The smaller these objects, and especially when near to us, the greater is the effort needed to render the image distinct. It is well to remember, then, that reading many books and expressing ourselves by much writing are comparatively new things in the development of human life, and when we impose these upon children, we are subjecting them, in a way, to a new order of things. Under the best conditions obtainable we are thus putting a great burden upon the organs of vision and through them upon the nervous mechanism of the brain. But if this be true under the best conditions of light and posture, how much greater the burden becomes under unfavorable conditions, we may know by reference to the increasing abnormalities of vision developing year by year in our schools. From all parts of the civilized world evidence is at hand that the eyesight of school children is increasingly defective, and that the danger does not stop with mere inconvenience of vision or inadequate sense perception, but that these defects react upon their general health, producing nervous headaches, derangements of the nervous system, and the ills incident thereto. In his discussion of this point of view Professor Scott says: —

"The human eye which was evolved for distant vision (beyond about four feet) is being forced to perform a new part, one for which it was not evolved, and for which it is poorly adapted. . . . All things seem to be conspiring to make us use our eyes more and more for the very things for which they are the most poorly adapted. It requires no prophet to foresee that such a perversion in the use of an organ will surely result in a great sacrifice of energy, if not of health and of general efficiency."[1]

We must remember, however, that very young children have the power to accommodate for near objects and can apparently see them clearly even though very small. Children under a year of age are often able to see a small object, even a speck on a table, and at times they seem to take delight in exploring such objects with the finger tip. The trouble lies in the strain of long-continued endeavor, and especially if the illumination is poor or the objects to be observed demand close attention in order to identify them. The day of books and writing has come to stay, and we must learn to use them effectively with the least effort, and so adapt our school and home conditions to the limitations of our physical powers and the demands of health.

Is Civilization harming Human Vision? — Those who would frighten us into believing that the demands of modern conditions are bringing about serious degeneration of human vision have, in no sense, any rational basis for their conclusions. They unhesitatingly tell us that the savages had perfect vision, and could, with their "eagle eyes," see far better than we. This doctrine is more mythical than real. There is no sound scientific data from which to draw such conclusions. In fact, it seems to me that on broad lines, all evidence points to increasing natural power and efficiency. It is not at all likely that our children are born with more defective eyes than are the children of savages, and we know that far fewer infants born into civilized life lose their

[1] *The Sacrifice of School Children*, by Professor Walter D. Scott, Popular Scientific Monthly, vol. 71, p. 304.

sight through lack of proper care in early infancy than is the case with those born under uncivilized conditions. But this is the thing for us to consider carefully, savage children had no books, and they did not spend a greater part of their day in schoolrooms, reading and writing. They were not compelled to sit at flat desks over which they must bend, in order to bring their eyes into proper relation to their work. Neither was their work, whatever its kind, so continuously exacting. Hence whatever defects existed offered less trouble.

We must not get a notion that because more glasses are worn in our generation our vision is degenerating. It may be that this is simply evidence of greater carefulness! But we cannot deny the fact that some of our children, indeed many of them, would have far better vision and better health if they were not subjected to the eyestrain of present-day school demands. These demands are not necessary. In the main they result from lack of knowledge and willingness to adjust our work accordingly.

Testing the Vision of School Children. — Wherever the sanitary conditions of school buildings and school children are under medical supervision, the physician in charge ought to be, and generally is, held responsible for all tests of vision and hearing and those that have for their purpose the diagnosis of the general physical condition of the children. But it will be a long time before the country school will be brought under adequate medical supervision, and until that time comes the teacher must know how to test the children, especially for defective vision. All that she needs to know and apply is a reliable and simple method by which she may determine whether any defect exists, and in a general way how serious this defect is. The teacher who has not had careful training as an oculist ought not to diagnose the cause of any defective vision found; but she ought to be able to determine whether a child has normal or subnormal vision. By the use of the Snellen test card it is generally easy to do this. And when a

child is found whose vision is so far subnormal as to make it clear that the child is not only working at a great disadvantage, but probably adding to the difficulty by continued eyestrain, then it may readily and truthfully be said the child does not see well, and its eyes ought to be examined by a competent oculist, so that, if needed, glasses may be prescribed, or its general health may be looked after.

Use of the Snellen Test Card. — County superintendents should see that every country school is supplied with one of these test cards, and that the teachers are trained to use them judiciously. They are inexpensive, costing but a few cents, and when carefully used, may save many children much suffering. Their use directs the attention of the teacher to the need of better care for those who are defective as well as for those whose eyes have not yet yielded to the unnatural demands of school life.

The Snellen test card is the standard for testing the acuity of the vision of all persons who know the letters of the alphabet, and each card shows how far the letters ought to be seen by the child, when the illumination is equal to that of good daylight well dispersed. No further direction need be given here save to say that the eyes should be tested one at a time and the percentage of acuity for each noted.

Test for Astigmatism. — Some of these test cards have, in addition to the Snellen letters, various figures or letters printed in such a manner as to furnish tests for astigmatism.

It has been pointed out previously that astigmatism is the most common defect and, in aggravated cases, is the source of a great deal of difficulty. The ordinary teacher, after some practice, can use such tests to advantage, but much depends on the handling of the children to prevent suggestion. In no case, however, ought a teacher undertake to do more than to find out whether or not real difficulties exist, and then she can advise parents and pupils alike as to the need of professional care. By coöperative efforts the teachers in the country and

the oculists of the neighboring towns may do much to bring relief to those who are ignorant of their visual defects and the handicaps that these bring. Many people have gone through life never knowing the world outside clearly and distinctly. Many myopic people develop a sort of "myopic character," because the world of clearest vision is limited to a small area in their own personal environment.

Cases of Superacute Vision. — There are some cases of superacute vision which need attention even though the Snellen card would not indicate any defect. Temporarily supersensitive retinæ may indicate an overwrought condition. Such eyes readily fatigue, cause headaches and increased nervous exhaustion. These cases must not be confused with those where the eyes are naturally acute for distant objects. As noted before, local environments may account for differences in visual acuity. Cohn called attention to the fact that children brought up in mountain regions seem to have keener normal vision for distant things than those whose eyes have habitually rested on nearer objects.

TOPICS FOR INVESTIGATION

1. Test the eyes of your pupils carefully by use of the Snellen card, and try to understand the variations found.
2. Should children deal with the larger and more obvious things in their nature study work? Why?
3. Observe the effect of a high degree of myopia on the character and mental habits of people so afflicted.
4. Why is it difficult to detect a case of hyperopia by the ordinary school tests?
5. How may hyperopia cause eye fatigue and eye strain?
6. Is myopia cured by glasses?
7. How could it happen that children may have a high degree of myopia and not be conscious of any difficulty?
8. If you have a pupil with a high degree of myopia, and his parents refuse to get properly made glasses, how can you manage to teach him most effectively so as not to add to the difficulty?

9. Why does astigmatism often produce headaches?

10. What are the dangers and inconveniences of strabismus (crossed eyes)?

11. What do you think of the effect of much home study on the eyesight of school children? Why?

12. What types of children are most likely to show asthenopia (weakness of vision)? Would the Snellen card necessarily detect these cases?

SELECTED REFERENCES

ALLPORT, F. *The Eye and its Care.* Philadelphia, 1896. 174 pp.

CARTER, R. B. *Report on the Vision of the Children attending Elementary Schools in London.* London, 1896. 16 pp.

COHN, H. *Eyes and School Books.* Pop. Sci. Monthly, v. 19, p. 54.

COHN, H. *Hygiene of the Eye.* London, 1886. 236 pp., illus.

GARIEL, C. M. *Hygiene Oculaire et Inspection des Écoles.* Paris, 1911. 244 pp., illus.

JAVAL, M. *Daylight in the Schoolroom.* Pop. Sci. Monthly, v. 16, pp. 517–519.

MARTIN, G. H. *School Hygiene in Massachusetts.* Board of Education. Boston, 1908. (See especially on eye and ear tests.)

RICE, D. E. *Visual Acuity with Lights of Different Colors and Intensities.* New York, 1912. 59 pp., illus.

ROOSA, D. B. *Defective Eyesight,* etc. New York, 1889. 186 pp., illus.

SCOTT, W. D. *The Sacrifice of the Eyes of School Children.* Pop. Sci. Monthly, v. 71, pp. 303–312.

SWIFT, E. J. *Eye Defects in Students and Children.* Pedagogical Seminary, v. 5, pp. 202–220.

WEEKS, J. E. *The Care of the Eyes of Children while at School.* Teachers College Record, v. 6, pp. 30–42.

CHAPTER XVI

THE HEARING OF SCHOOL CHILDREN

Causes of Defective Hearing. — Due to no fault of school conditions, a varying number of pupils in any class have defective hearing. This is usually the result of colds, scarlet fever, diphtheria, adenoids, or accidents of one form or another. The teacher cannot correct these defects, but she can adjust her work to those so afflicted as to make it less of a strain for them to do the work assigned them. For example, poor spelling may, and often does, result from the inability of the child to hear clearly and perfectly the definite sounds of the spoken word. Indistinct and imperfect enunciation often results from defective hearing. But if a teacher knows which of her pupils are defective in this particular, she can place them in the most advantageous position for hearing, and she can likewise take special pains to speak distinctly and with more force if needed. Naturally it will be helpful to call the parents' or school physician's attention to the defects observed, for the deafness may be only temporary, and if taken in time, serious results may be forestalled.

Tests for Hearing. — In schools where a medical inspector is employed, it is his duty to make tests and to report the results. But in country or village schools where medical help is not furnished, the teacher herself can make tests that may greatly aid her in understanding the relative degree of deafness from which any of her pupils is suffering.

One of the best tests for teachers who have not been especially trained, and who do not have access to the more exact ap-

paratus designed for this purpose, is that known as the watch test. This test is performed in the following way. Seat a child comfortably, and blindfold him so as not to interfere with his hearing. Fasten one end of a tape line to the wall on a level with the child's ears, and the other on a string running at right angles to the tape line, and close to the child's ear. Test one ear at a time by finding out how far away he can hear the watch tick. It is better to use a large clear-ticking watch, preferably a stop watch. While one ear is being tested, the other ought to be turned away and covered with a thick pad of cotton or something that will bar the sound waves. It is sometimes necessary to experiment several times in order to make sure that the child is not guessing. Thus, with care, it is comparatively easy to find out how far away the watch may be heard with each ear. By testing all of the children in this way, those who are defective will be found.

Another simple test, the whispering test, has been used to advantage. This consists in finding how far a child can hear and distinguish a given list of words or numbers when spoken in a whisper. The difficulty with this method lies in the inability of the teacher or experimenter to regulate the force of the whisper. The watch method is preferable.

The Disadvantages of Defective Hearing.--A child who does not hear well is at a disadvantage in many ways. He is usually sensitive about his defect and often prefers imperfect understanding to making repeated requests for information. He is likely to become careless and to take many things for granted. Those who are seriously defective become suspicious of others and may develop a morose temperament. Besides all these, a child who is hard of hearing is handicapped in many ways in learning, and his voice may become unnatural and unpleasant. It is therefore of great importance to guard the children against any accidents or unhygienic conditions that would interfere with their hearing, and to give special attention to those who are defective.

TOPICS FOR INVESTIGATION

1. Find out by careful tests which of your pupils are defective in hearing, and whether the defects that they show are permanent or merely temporary.

2. Why are deaf people often inclined to be suspicious and sensitive?

3. Note carefully the quality of the voices of those who are suffering from permanently defective hearing.

4. How far, through improper sanitation, thoughtless punishment, or lack of health directions is the school responsible for faulty or defective hearing?

5. Study carefully the relationship between adenoids and defective hearing.

6. Note what pupils, if any, are subject to colds in the head, and whether they also suffer from headaches. Why should one so afflicted be warned against forcibly blowing the nose?

7. Note whether or not those who have defective hearing are mouth breathers.

SELECTED REFERENCES

BEZOLD, F. *Schuluntersuchungen über das Kindliche Gehörorgan.* Wiesbaden, 1885. 94 pp.

CHRISMAN, O. *The Hearing of Children.* Pedagogical Seminary, v. 2, pp. 397-441.

BRUNER, F. G. *The Hearing of Primitive Peoples.* New York, 1908. 113 pp.

CHAPTER XVII

THE TEETH OF SCHOOL CHILDREN

ALL thinking people know that the teeth perform a very important function in the preparation of the food for digestion and assimilation. But comparatively few people are willing to take the time and trouble or bear the expense of preserving their teeth. They know that health and strength depend on proper nourishment, but they are negligent in a thousand ways of the quality, quantity, and proper preparation of food. Here, as in all activities of life, habits slowly but surely fasten upon us a routine which will help or hinder. Habits of personal hygiene, as most other habits, are most easily and firmly fixed in youth. Children who grow up without being trained to regular and consistent care of their teeth not only invite dental decay, but are establishing a habit which will throughout their lives make for carelessness in personal cleanliness and all that tends to insure a clean, wholesome mouth. Intelligent, careful parents who realize the importance of the care of children's teeth, and know something of the formation and power of habit, will, of course, train their children to care for their teeth and in addition will afford them such professional care as their needs demand.

No one is more loath to suggest an increase in the burden of responsibilities teachers carry than I, and no one is more anxious to impress upon fathers and mothers the importance of doing their whole duty to their children; but when we learn from results of examinations made of hundreds of thousands of children in this and foreign lands that at least seventy-five per cent of the school children have diseased teeth, that a very small percentage of them get any training in the care of their teeth,

and that most of them have never been taught to use the tooth-brush, we are forced to the conclusion that public school teachers must undertake to teach the youth of our land some of the fundamentals of oral hygiene, and must also, as far as possible, coöperate with the parents in developing in the children the habit of properly caring for their teeth.

It is not my intention to give in this chapter any exhaustive discussion of dental hygiene; but rather to emphasize in a practical way what can be done in schools to help save the children from that sinful neglect to which attention has been called.

Causes of Dental Decay. — Harmful bacteria will get into our mouths despite all that we can do, and if remnants of foods, especially those containing starch or sugar, are permitted to remain in the mouth between meals and especially between supper and breakfast, certain of these bacteria will rapidly develop, for the moisture and heat of the mouth cavity furnish an ideal condition for their rapid growth. As a result of this growth putrefaction of these food particles takes place, and various kinds of acids are formed. These acids slowly dissolve certain elements composing the enamel, or hard covering, of the exposed parts of the teeth, and by and by small pits are formed in the more protected parts. These naturally grow deeper, for they furnish added opportunity for bits of food to find lodgment, and for the bacteria to work undisturbed. As these pits, or caries, as they are called by dentists, grow deeper, the more porous substance of the teeth, called dentine, is exposed, and the decay of the tooth becomes more and more rapid, until finally the whole tooth and the nerve connected with it is involved in the trouble.

A sound, clean apple with a good glossy peel will keep a long time, simply because this covering is able to resist the entrance of destructive bacteria, but if that peel is pierced or broken, and sufficient heat and moisture are present, decay will begin and in a short time a rotten speck will be noticeable. Progress

of decay is at first comparatively slow, but if unhindered, it increases in geometric ratio until the whole apple is destroyed. As long as the peel of a sound apple is kept clean, and unbroken, the softer material within is protected. So with the teeth. Nature provides, when proper nourishment is afforded before and after birth, that the teeth of all normal children will be protected from disease by this hard covering of glossy enamel. The individual must keep it clean and shield it from such usage as would tend to break or destroy it. It is the armor of health upon which myriads of invisible foes may beat harmlessly, if no lodging place is allowed them. No ancient warrior would have dared to meet his foes in mortal contest if his battle armor were rusty and eaten full of holes. If in the mouth of every adult man or woman in America to-day there were thirty-two strong dental warriors wrapped in glistening unbroken armor, our people would be guarded against innumerable ills. But unfortunately only a few people are thus supplied, and it is more than a personal problem for us to determine what ought to be done.

Dental Clinics in Schools of Europe. — The first school dental clinic in Germany was equipped and opened at Strassburg in Alsace, in 1902. In the two years following the teeth of two thousand girls and two thousand boys were carefully examined. More than thirty per cent in each group showed that one third of all their teeth were diseased. The teeth of the girls were more defective than those of the boys. Of these four thousand children, only one hundred and four had perfectly healthy mouths. In the two years following approximately the same conditions were reported by other investigators in a dozen of the largest cities in Germany. Investigations in Denmark, England, Italy, Norway, Austria, Russia, Sweden, Switzerland, Hungary, and our own country show that the conditions are almost equally distressing. One of the astonishing facts that has come to light as a result of the examination of the teeth of school children is that, in most

instances, children from the homes of the more intelligent and well-to-do classes are as improperly cared for in this respect as those from the poorer and less intelligent classes. The school medical officer for Bradford, England, reported, in 1908, as result of an examination of "1491 children between the ages of five and thirteen years, 743 of whom attended a school in one of the better-class districts, and 748 who attended two schools situated in the poorest districts" the following facts: —

School in	Per Cent with Sound Teeth	Per Cent with not more than 3 Decayed Teeth	Per Cent with 4 or more Decayed Teeth
Better-class District . .	4.72	19.51	75.77
Very Poor District . .	7.62	26.06	66.32

A dentist employed by the authorities of Cambridge Borough, England, to examine into the condition of the teeth of school children reported in the same year that he had examined 2946 children, and "the percentage of children with perfectly sound teeth, which in the third and fourth years stood at a little over eleven per cent, had fallen by the sixth and seventh years to two per cent, and by the tenth to the fourteenth to zero." "If," he adds, "the temporary teeth be ignored, the percentage of children with perfectly sound permanent teeth at five years is just over sixty-four per cent, dropping at seven years to twenty-four per cent. It then falls more slowly to a little over six per cent in the ninth year, and after continuing almost stationary until the tenth year sinks to less than two per cent in the eleventh, and after this remains more or less stationary. At thirteen and fourteen years half the children have each nine or more permanent teeth carious."[1]

Results of Examinations in the United States. — We are told in the reports of dental examiners that "the teeth of 75 per

[1] Annual Report of Chief Medical Officer of the Board of Education, 1908, p. 55.

cent of the school children of Cincinnati need attention. In nine schools 25,514 children were examined (1910) and only 958 were found with no defects, and many of these needed to have their teeth cleaned." In March, 1909, 36,403 children were examined in the public schools of Cleveland and of these " the teeth of 27,918 were found to be defective, while in some classrooms as high as 95 per cent were deficient in this respect." In Reading, Pa., the teeth of school children were examined in 1910 by twenty-five of the dentists of the city, and it was found that "less than 3 per cent of these had perfect teeth." It was also found " that of nearly 9000 boys and girls examined in the winter of 1909–1910, only 4849 had ever used a toothbrush, only 1369 had ever been to a dentist and 1094 of these had had permanent teeth extracted." As a result of dental examination of about 2000 school children in Cambridge, Mass., in 1910, the dentists report " the mouths of the older children in a deplorable condition, quite 95 per cent need immediate attention in order to save what few teeth can be saved. The condition of the younger children is a little better, although most of the sixth-year molars need immediate attention to save them. Very few of the children examined give their teeth any care, even the toothbrush being little used."

Dental Decay Rapid during the School Life. — It seems unnecessary to quote statistics at greater length. If the figures given overestimate the conditions somewhat, and we should reduce the number of those marked defective by ten per cent, the results would show a situation demanding immediate attention. From a study of the reports of examinations made on hundreds of thousands of children, it is a very conservative estimate to say that not twenty in every one hundred school children of the intermediate grades have what may in any sense be called a normally sound set of teeth. But it will be noticed also that the decay is very rapid during the first years of school life. and that by the time the child is ready to

leave school his teeth are in a serious condition. If the teeth are to be saved at all, they must be saved by proper care and proper use between the ages of five and fourteen years. It is a significant fact that if a child can be brought to the age of sixteen or eighteen years with sound teeth, he is not likely to suffer seriously in after life from defective teeth, for not only will the habit of keeping his teeth clean, and of using them judiciously, continue with him, but the teeth themselves will have acquired a consistency and strength capable of greater resistance to the ordinary causes of decay. If teachers and parents realize the true significance of these facts, it is safe to conclude that the children will greatly profit by the knowledge. While of course the teeth are subject to decay at any period of life, it is still true that childhood is the period when this decay is most rapid and most easily induced.

Causes of Increasing Dental Decay. — The question of the cause of the great amount of dental disease has been discussed by a great number of specialists. The following conclusions seem to be pretty generally accepted: —

Soft Foods induce Decay. — The teeth of children are not given enough proper exercise in these days of mushes, soft breads, and breakfast foods. It is a general law of nature that an organ of the body will be undeveloped and subject to degeneration if it is not exercised according to the demands that have produced it. Human teeth were developed to meet the demands of the coarser foods. When these coarser foods are ground up by machines, the teeth are not permitted to perform their natural function.

The suggestion for relief here implied is therefore one of proper food supply. Furthermore, active vigorous exercise of the teeth on foods that need good grinding to prepare them for digestion keeps the teeth polished and comparatively clean. Bacteria cannot easily gather and maintain their hold on the crowns of the teeth, if these are used in grinding the harder materials of food. But breakfast mush, and other soft foods,

which nobody can chew with any satisfaction, will gather in the crypts, and unless removed by a brush will soon develop busy colonies of bacteria. It has been said time and again by competent authority that carious teeth are products, to a considerable degree of modern civilized life, for children are largely fed on soft-cooked foods, and hence do not get sufficient exercise to keep their teeth well polished and strong.

FIG. 45. — Teaching teachers how to use a toothbrush properly. University of Alabama, Summer Session

In a most interesting article in the *Dental Cosmos* for July, 1908, Dr. Louis Ottoff, a dentist of Manila, gives an account of some investigations that he made on the teeth of the Igorots of Bontoc, in northern Luzon. He found that the teeth of the Igorot children were almost perfect. He says that the percentages of sound and carious teeth of the permanent set show that the teeth of Americans and Filipinos are ten times as bad as those of the Igorots. He attributes this remarkable

perfectness of the teeth of the Igorots to their vigorous, outdoor life; the use of, in the main, a vegetable diet, so cooked that much mastication is required; and the use of little or no sugar. They never use a toothbrush, and only occasionally scrub the teeth with wet sand while they are bathing in the streams.

Insufficient Lime in Food and Drink. — It appears, also, that many children are not getting sufficient lime in their food and drink to meet the demands for the growth of their teeth and bones. This may be due in part to the fact that the great majority of people in cities and towns are using surface water instead of spring or well water, and hence there is less chance for them to get the supply of lime needed. Investigations seem to show that in limestone countries, where drinking water contains a larger per cent of lime, other things being equal, diseased and weak teeth are less common. Besides, the children of cities are not, as a rule, getting sufficient milk supply to meet the demands of normal growth. Good milk contains a comparatively large percentage of lime salts, and if furnished as one of the chief diets of children, will supply the needed material for the growth of the teeth and the bones.

Need to teach Children how to use the Toothbrush. — The immediate cause of most dental diseases is lack of cleanliness. Since the use of soft foods has become so general, greater diligence is needed in keeping the teeth clean. Caries are nearly always either in the crypts of the crowns or between the teeth, where particles of food lodge and decay. Toothbrushes are therefore more needed to-day than formerly, and the children must be habituated to their intelligent use. It is even true that most people do not know how to use a toothbrush properly. They rub it back and forth across the teeth, instead of up and down and across the crowns, so as to allow the bristles to dislodge the food particles that gather between the teeth and in the crypts. Fewer still apply the brush to the inner surface of the teeth.

The Oral Hygiene Committee of the National Dental Association has found it necessary to institute toothbrush drills, in order to teach public school teachers the proper use of the toothbrush, so that they may use similar methods in dealing with their pupils. In the same way nurses and teachers in those cities where dental clinics have been established have found it necessary to give specific instruction in the use of the toothbrush before satisfactory results could be obtained. Since the gums

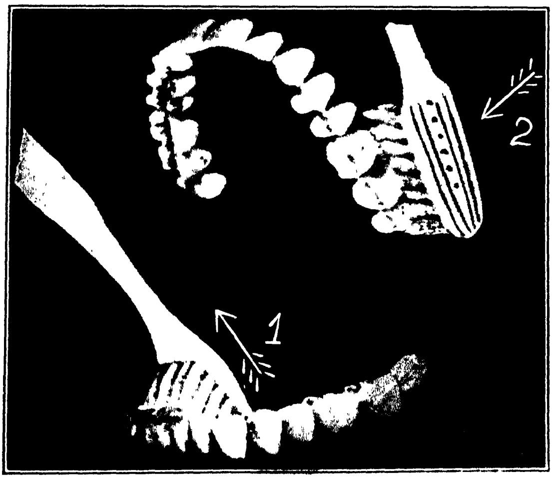


FIG. 46.—Proper method of using a toothbrush. By special permission of Dr. M. H. Fletcher, and the *Dental Summary*.

need cleansing and brushing to keep them in a wholesome and healthful condition, the toothbrush should be placed in the mouth with the bristles directed toward the roots of the teeth and then brought over the gums and teeth with a twisting movement. This will keep the gums healthy and cause the bristles to dislodge food particles between the teeth. A special hoelike brush has been devised for the inside of the incisors. An ordinary brush will meet the requirements for other parts of the mouth.

It is evident, however, that the deeper and more numerous the caries in the teeth, the harder it is to remove thoroughly the food particles lodged in these cavities. Besides, as suggested, the crowns of the teeth are often neglected and here in general is the place where the first caries are formed. Crooked and badly set teeth are, of course, more difficult to keep clean than those in a well-formed jaw, and this point naturally suggests help for those with impacted and crooked teeth.

Decayed Teeth and Germ Diseases. — Not only does a habitually unclean mouth furnish the conditions for dental diseases, but also for the lodgment of many varieties of pathogenic germs. Careful examinations of the mouths of school children have revealed the presence in the decayed teeth of germs of diphtheria, tuberculosis, pneumonia, and influenza. It has not been established in any scientific way that epidemics have been started from such sources, nor that there is grave danger of contagion from defective and infected teeth, although this appears to be clearly possible, and, indeed, may have repeatedly happened.

An Offensive Mouth. — An unclean and ill-kept mouth is not only insanitary; it is both disgusting and ugly. A mouth in which particles of food are allowed to rot — an ugly word, but warranted here — always emits with every spoken word the odors generated by putrefaction. People who are so careless can never be really polite and inoffensive. On the other hand, a mouth with a full set of clean, well-polished, and well-set teeth is always attractive.

Effect of Adenoids on Dentition. — Adenoids, if not early removed, so dwarf and narrow the upper jaw that the teeth overlap, emerge at the wrong place, and become so crowded and displaced that they are weak and ineffective, because they do not properly strike the teeth on the lower jaw. Such deformed mouths are ugly, and often defy the skill of the best dentist to correct. Teachers and parents ought to see that children suffering from adenoids get early attention. In this con-

nection it is well to mention the effect of the use of so-called "baby pacifiers," and hard rubber nipples for bottle feeding. Those rubber nipples that babies are allowed to suck simply to keep them from crying are often responsible for narrowing the upper jaw by raising the arch and drawing the incisors forward. They press against the roof of the mouth so as to raise it higher and hence narrow the jaw. These "pacifiers" are not only abominable from the general health point of view because they are usually dirty, but their persistent use will deform the baby's mouth.

Good Teeth in Articulation. — Good teeth normally placed greatly assist in good articulation. A wide, low arch and well-spaced teeth make it possible to avoid many lisping, hissing sounds, to which the English tongue easily lends itself. While there is no desire to state this as a chief reason for the proper care and treatment of the teeth of children, I do want to say that is by no means a small matter. Good, clear, well-articulated utterance is worthy of painstaking effort from everybody.

Deposits on the Teeth. — A deposit that the dentists call tartar often forms on the teeth near their insertion in the gums. This is due to precipitation of mineral matter contained in the saliva and fluids present in the mouth. This deposit is especially noticeable on the inner part of the lower incisors, and sometimes becomes so incrusted and hard as to require a dentist to separate it from the teeth. It needs no argument to suggest to a thoughtful teacher that children should be taught to keep this tartar removed, for it tends to separate the gums from the teeth, offers opportunity for the absorption of acids and other deleterious matter, in time will get between the teeth, and will befoul the breath. It discolors the teeth and will eventually injure the enamel and cause the gums to ulcerate. Any teacher may easily see the deposits of tartar in a badly kept mouth, and one good observation will impress the need of care more than pages of earnest entreaty.

Care of a Baby's Mouth. — The chief emphasis thus far has been placed on the care of the teeth of school children, for there the results of carelessness show so plainly. But all dentists are agreed that much of the trouble starts with improper care of the baby's mouth. The temporary teeth demand protection, also, for only with their proper development and use may we expect the appearance of strong and healthy permanent teeth. From the very first, the baby's food should anticipate the needs for dental development, and baby's mouth must be kept clean and wholesome.

Tooth Powder. — Dentists are practically unanimous in recommending for tooth powder a good grade of pure precipitated chalk suitably flavored. It is best to use this powder dry and at least once a day after the evening meal. After other meals a good rinsing with the aid of the brush will suffice, though the powder may be used oftener if so desired.

Suggestions. — Here are a few short statements that teachers may find useful in impressing upon the children the need of keeping their teeth clean. A dirty mouth is a more serious menace to health than a dirty face. Teeth are worth more than diamonds, for without teeth perfect health is impossible. The stomach has no teeth. A sore finger may heal, a decayed tooth never. Retiring at night with a dirty mouth means rapid decay of teeth. Decayed teeth are the hiding places for the germs of contagious diseases. A foul breath means a dirty mouth. If you value good health, keep your mouth clean and consult a dentist twice a year. Exercise your teeth to keep them strong and clean. Teeth always decay from the outside. If it is impolite to appear in company with a dirty face, it is coarse to speak to a friend out of a filthy mouth. No feature of the face is more becoming than well-kept, perfect teeth. Artificial teeth are not one tenth as effective as natural teeth.

School Dental Clinics Important. — The time is rapidly approaching, whether we wish it or not, when there will be

connected with every local school system a dental clinic for the examination of the teeth of all school children, and for the treatment of those whose parents are either too poor or too careless to take proper care of their children. There seems to be no other way to insure the children's teeth against decay. Meanwhile all children and parents must be taught that the first years of school life are critical periods for preserving the teeth, and they should be instructed in methods of keeping their teeth clean, and in guarding them from decay. Here and there in our country, school dental clinics are now in operation, and their rapid development is only a matter of time. It is not an individual question; dental weakness is a fruitful condition for general weakness and contagion. Society must protect itself from those who, through neglect, later become burdens rather than helpers. Twelve of the most progressive cities of Germany in their dental clinics in 1911 treated 72,704 children at an average cost of twenty-five cents per child. It is significant that in Hamburg the Insurance Committee established dental clinics, in 1911, for their Domestic Servants' section, and is also lending its equipment to assist the school authorities in their dental work. This committee recently engaged to treat forty school children each day at a cost of twenty-six cents per child, about one half of the expense to be borne by the parents or the Poor Law Committee and the rest by the city authorities.

Recognized Importance of the Topic. — Dental Hygiene is a topic that is now being discussed in all parts of the civilized world, and its significance appears to be fully recognized by all classes of people who are solicitous for the health of the future citizen. Naturally, in the midst of the excitement caused by the revelation of the lamentable condition of the teeth of school children, many writers and reformers have overemphasized the relation of dental disease to the general welfare; but there seems to be no doubt in the minds of the most judicious that the situation is serious, and that dental disease is the most

widespread disease now afflicting civilized nations. With this in mind every teacher in our land has a civic duty to perform in helping to better conditions.

TOPICS FOR INVESTIGATION

1. Study carefully the effects of adenoids on dentition. See also the results of modern dental work in correcting these defects.

2. Devise some method of coöperation between dentists and school authorities so that country children may have better care of their teeth.

3. Are children with bad teeth usually defective in any other way?

4. Find a good method of caring for toothbrushes at school, and of giving toothbrush drills.

5. Teach children to save their teeth, by showing them that it is not always necessary to pull out a tooth even when badly decayed.

6. Why is it important to care for the temporary teeth?

7. Will clean mouths prevent boys from acquiring the evil habit of smoking cigarettes?

8. Examine the mouths of your school children and note what teeth decay first.

SELECTED REFERENCES

BURNHAM, W. H. *The Hygiene of the Teeth.* Pedagogical Seminary, v. 13, pp. 293–306.

MARSHALL, J. S. *Mouth Hygiene and Mouth Sepsis.* Philadelphia, 1912. 262 pp.

Report of Scientific Experiments, etc., on the Value of Healthy Conditions of the Mouth. Cleveland. W. G. Ebersole *et al.* April 1, 1912.

Virginia Board of Health. *Good Teeth and Bad; the Essentials of Oral Hygiene*, v. 3, No. 3, March, 1911. pp. 35–47, illus.

WALLIS, C. E. *The Teeth of the School Child.* School Hygiene (London), v. 1, pp. 396–399.

WHITE, P. G. *The Necessity of School Instruction in Dental Hygiene.* Dental Cosmos, v. 50, pp. 23–32.

CHAPTER XVIII

STUTTERING

More Boys than Girls Stutter. — It is a serious hindrance to a boy, and possibly more to a girl, to be afflicted with the habit of stuttering. There are, probably, five or six boys who stutter to one girl so afflicted. Just why boys are so much more susceptible to the acquirement of this habit has not been fully determined, though much has been written on this question. It is not worth while at this time to discuss at any length the reasons given for this disparity; but it may be of some general service to teachers to call their attention to the fact that girls mature earlier than boys, get control of their muscles more readily, and therefore are not so likely to fail in the complicated coördination of those movements necessary in speaking. Our problem, then, is mainly a problem with the boys, since girls overcome and, so to speak, outgrow this defect more readily than boys do. I wish to impress upon all teachers the duty that they owe to these unfortunates. It has been my observation that there are few teachers who feel it their duty to undertake any systematic correction of this fault, for the reason that it requires individual help and is, therefore, apparently somewhat out of the line of regular school work. But are these boys and girls who are thus afflicted to be allowed to acquire this habit for life, or shall the public schools undertake to help them? It is the duty of the public school in all cases where private help is not obtainable.

Predisposing Causes. — The predisposing causes that are largely responsible for stuttering are: a general nervous diathesis, or an overanxious temperament. This may be

due to inheritance, disease, or accident. A child whose nervous and physical control is unsteady and somewhat explosive is readily affected, and the muscles required to make the delicate movements and coördinations necessary in accurate speech are quite easily thrown into spasms or cramps. Just how much of the difficulty is due to inheritance, it is impossible to say. But there seems to be no doubt in the minds of most of the specialists in this field that a child born of stock with depleted nervous energy, and undue impression ability, is more likely, other things being equal, to develop this defect than one whose birthright is of a nobler sort. It has been found that stutterers belong, very often, to families that show, in near or remote generations, an abnormal amount of nervous diseases. On the other hand, diseases, especially those that deplete the nervous system in childhood, may predispose a child born of good stock to this troublesome habit. In this connection, it is well to call attention to those defects and ailments not generally reckoned as diseases, which often seriously handicap children and induce the weaknesses associated with many stutterers. Adenoids, continued indigestion, weakness in the power of assimilation, overexertion, general anæmia, and undue emotional stimulations are all predisposing causes to stuttering.

Imitation an Immediate Cause. — Many, perhaps most, cases of stuttering find an immediate cause in imitation. Children whose nervous systems are unsteady and easily upset are endangered by association with those who speak in an uneven, blustering fashion. Here the responsibility lies with the home association and training. More than three fourths of all children who develop the habit of stuttering make a beginning before they reach school age. Denhardt found that of 6206 cases, more than eighty-seven per cent were stuttering before they entered school.[1]

[1] Das Stottern, R. Denhardt, p. 101. Quoted from Conradi, *Pedagogical Seminary*, v. xi, p. 356.

Conradi, in his excellent study of *Speech Development of the Child*, gives the following summary of points relative to defects in speech: —

"1. Inheritance seems to be a predisposing factor.

"2. Anything that disturbs the nervous system of the child may be an immediate cause, especially acute disease.

"3. Suggestion is a factor in the spread of the disease.

"4. Stuttering is a children's disease.

"5. *Second dentition and puberty are periods that favor stuttering.*

"6. Boys are more subject to the trouble than girls.

"7. It probably retards pupils in their school work.

"8. Stutterers are not (naturally) mentally inferior.

"9. Speech defects are often the source of severe psychical depressions.

"10. The seriousness and the spread of the trouble is such that it deserves more attention from the public and the specialist than is given to it in this country at the present time.

"11. Stuttering and stammering are, with probably a very few exceptions, curable." [1]

The question now arises, How can public school teachers help those who suffer in this way?

What can Teachers do for Stutterers? — First: In all city systems of schools some specially prepared and capable teacher should be selected to take charge of such pupils, at least for some part of each day during regular school hours, and also to give direction to their regular teachers so that consistent and persistent effort would be regularly demanded of them. Since the work must be largely individual, and since, also, there is a risk in bringing together several stutterers in a single class on account of the danger of suggestion and imitation, it is not well to form a class of such pupils. Let them come singly for a short period each day and rigidly enter upon a special program of exercises varied to suit their individual needs. Here, removed from the embarrassment incident to class work, under the sympathetic care of one whose only

[1] *Speech Development in the Child*, Edward Conradi. Pedagogical Seminary, v. xi, pp. 375–376.

purpose is to help him, much good may be accomplished in a short time.

Second: District school teachers in assisting stutterers ought to set apart a little time every day, after school hours if need be, to give them special drill, and to study their difficulties. Yes, it will take time; but the time will be well spent. Doubtless, some arrangement may be made with the local boards and the county boards as well, whereby schools can close a few minutes earlier, or, better, where some additional stipend will be granted for this special service. Some way should be found to give these children systematic help, and the teacher who undertakes it will find most interesting, as well as useful, service.

It would be impossible to give here a detailed method of procedure for overcoming this annoying and distressing weakness of speech, for, to a certain degree, *each* child must be studied and his individual weaknesses treated; but there are some broad general rules that it may be worth while to consider, both for the purpose of creating an interest in this phase of professional work, and for the suggestions that they may develop in those who know how to use general rules.

Suggestions to help overcome Stuttering. — 1. Stuttering and stammering are the results of uncoördinated movements of the organs of speech. The organs of speech concerned in these movements are the muscles of the lower jaw, tongue, lips, cheeks, throat, vocal cords, diaphragm, intercostal muscles, and, in some cases, the muscles controlling the movements of the head as a whole. If to accomplish a given result the fingers of the right hand must be put down in a given order, then training will bring this about. For example, if one wishes to learn to play on a piano, the fingers must be capable not only of rapid consecutive movement, but all sorts of combinations in position, time, and force are needed. So it is in speaking a word. The sounds must come in their order, with the proper time, force, and intonation. Each different

word demands a different combination of these movements. A stutterer cannot always make certain combinations without repeated efforts. Plainly, then, the problem of his relief is to find out where his difficulties lie and set to work to give him ready control of them. If, for example, he cannot say the word *n-o-t*, without frequent repetitions of the sound for *n*, then it is plain that the tongue, the vocal cords, the muscles controlling the chest, and perhaps those controlling the jaw do not act in their proper order. Hence, here will be suggestion for specific drill to bring these into the order required. Begin slowly, in a quiet way, and repeat again, and again, and still again. Patient, continued effort will bring results.

2. Pupils must learn to hear exactly the sounds that you wish them to make. This rule will apply to all children, whether they stutter or not. A clear idea of a sound, vowel or consonant, will help very materially in its production. A man has little difficulty in walking a beam three feet wide without falling off if the beam lies on the ground. But suppose the beam were to span Yosemite Valley, where a misstep would mean a drop of a mile, would it be easy? In the first case the thought would be wholly given to walking the beam; in the second, he could hardly keep himself from thinking of falling, and his emotional state would be affected by thoughts of this dreadful contingency. And here lies the difficulty. If a boy who stutters can be taught to concentrate his thought on the definite successions of sound that he is to make, he has mastered one of his chief deficiencies. If his attention is directed toward probable failure, he is more than likely to fail.

3. Along with the control of thought will go control of emotion. Nearly all children who stutter or stammer show greater inability to enunciate when excited or when disturbed by some emotional situation; and this difficulty increases with the growth of sensibility and bashfulness, shown in the presence of others as adolescence approaches. There is a double duty here suggested for the teacher: prevent, as far as possible,

those emotional disturbances incident to recitations in which the stutterer makes blunders and stands embarrassed before the class; break up the defect as early in life as possible before the force of habit and the development of sensibility augment the difficulties. As suggested above, an isolation from classmates during special drills will help materially.

4. Control of the breathing is an essential factor in gaining power over speech. Definite and continued drill in taking breath, and especially in expiration, are very important. Any teacher who knows a system of calisthenic exercises devised for this purpose can give directions and drill in such work.

5. Along with these breathing exercises there should go exercises in singing. Almost no stutterer is troubled in singing, for his attention is in tone, and he articulates the words so slowly that the coördinations are made without stumbling. Tables of vowels, of consonants, and of the two combined should be constructed to remedy the defects of each case. Here some experimenting must be done, and daily drill required. Without doubt one of the difficulties of a purely mental sort that a stutterer must overcome is the tendency or wish to speak a whole word at once; a sort of vocal disgorgement as it were. Such a habit must be broken up at all hazards. The teacher should help him and train him to hear the tones in their order, think them together, and then speak them slowly. One who through such help breaks himself of stuttering may and ought to become a clearer, better speaker than one who has not had such difficulties to contend with.

Along with all these specific helps general physical education is perhaps of paramount importance. Coördination and control of the larger muscles give a firm foundation for control of the more accessory movements. Stutterers are not necessarily weak and anæmic, but they have not developed that general poise and control necessary to precise and well-defined delicacy of movement essential in speech.

6. Purity of tone is an end worth seeking in all vocal work, and with all children; but it is especially important with these defectives. If a child can learn to distinguish good quality of tones from poor, and can acquire ability to produce such quality, he can think tones more clearly and actively than one, other things equal, who has not been trained to do so. Purity and accuracy in vocalization are closely associated.

Gutzmann, in his excellent discussion of this defect, gives the following general rules for the guidance of one who wishes to overcome the habit of stuttering:[1] —

(*a*) Speak slowly and without effort. To this end orderly listening and undisturbed thinking are necessary.

(*b*) Speak in a moderately loud tone.

(*c*) Have clearly in mind what you want to say and how you wish to say it. "First think, then begin."

(*d*) Guard yourself from the inclination to bring everything to expression at once; but speak syllable by syllable, word by word, and thought by thought.

Stammering and Stuttering. — While the words "stutter" and "stammer" originally meant the same thing, the latter term has come to be applied more frequently to those phases of speech defects illustrated by the person who hesitates or balks in his speech. This defect may appear as a slight impediment, or hesitation, or it may become so serious as greatly to limit the usefulness of the unfortunate who labors under such a handicap. The pronounced stammerer makes facial contortions, inarticulate grunts, hisses, or gasping sounds. His actions portray a violent cramping of the muscles controlling breathing, those controlling the proper use of the jaws, or even the outer facial movements. It is painful to see a stammerer in the midst of an attempt to speak. It requires little observation to see that the mind of the stammerer is, during this physical spasm, in a corresponding tonic condition. No two persons so afflicted, however, exhibit the same forms

[1] See *Das Stottern*, Albert Gutzmann, II Tiel, p. 18.

of inability. With some it is merely a period of total incapacity to utter a sound, or even to open the mouth. Others gasp and struggle noisily, but cannot proceed. Still others shake their heads, roll their eyes, and, in fact, try to speak with the whole body. This inability may proceed so far as to simulate at times a slight epileptic seizure.

Mental Condition of the Stammerer. — The mental condition of an adolescent who stammers is a complex no one can fully analyze. But there are certain fundamental aspects of emotional stress that can be somewhat clearly made out. He is keenly sensitive concerning his weakness; he is in the grip of a fear that he cannot dispel; he is largely a slave to a suggestion that he cannot overcome; he fears he cannot speak without hesitation and that he will balk if he tries. In his calmer, intellectual moments the power and vividness of this suggestion is at its minimum. But with the advent of some emotional stimulus the ghost of this fear is ever present and doubly forceful. Just as objective ghosts, if this appellation can be allowed, are seen only at night, so subjective ghosts appear in the mind under the stress of emotion.

It is not a matter of mental weakness; it is rather the effect of emotional vividness fastened and nurtured by suggestion and the habits growing out if it. Those who have never been afflicted with stammering can never know the agony of a sensitive nature thus afflicted. But it is one of the highest gifts of a teacher to look out through the eyes of her pupils, to hear with their ears, and understand with their hearts. Blessed is the unfortunate stammerer who has the help of a teacher with such insight and willingness to undertake an intelligent correction.

It follows from what has been said that the cure for stammering is largely a mental cure. The subject must overcome fear with hope and slow but persistent gains. A counter-suggestion must be implanted, nourished, and trained to come to his relief. Scolding will make matters worse. Lack of

faith in final success will only serve to render the difficulty more insuperable. The vocal organs are capable, for at times the child uses them with precision. The brain centers are rarely diseased, and perhaps never in cases of pure stuttering or stammering. They can work well. All he needs is control, and this can come by eliminating fear, establishing faith and slowly but surely gaining a little each day. There will be relapses, times when faith weakens, but the wise teacher will comfort, inspire her pupil and calmly renew her efforts in his behalf. Younger children who are not so self-conscious, who do not feel so keenly their defects, will respond to careful direction in speaking, and to the quiet suggestions of control. But they should be removed from others who stammer, or those who nag them or laugh at their weakness. Each nervous system has its own index, and the teacher must study each individual for variations and hints to guide her. The fundamental point to remember is that the nervous system of a stammerer is unstable, and he will lose control under provocation.

The suggestions given for correcting stuttering will, in general, apply in correcting stammering. In stammering, however, the trouble seems more deep-seated and has taken a firmer hold of the emotional life as well as of the merely physical. It will require more patience and a more fundamental grasp of the mental life to deal with it successfully than with the simpler habits exhibited in stuttering. But the two defects are closely related and shade into each other imperceptibly, or even may both be exhibited by a single individual.

In conclusion, it may be said that the breaking of the habit of stuttering or stammering, just as the breaking of any habit, demands decision and persistent effort. Speak slowly, think clearly, concentrate attention on the thought to be expressed, and free the mind of excitement, anxiety, or dread. Read aloud slowly, and practice it daily. If the task is entered upon with full assurance, results will follow; but do not expect too much

in a short time. Every gain will operate to make the next gain more certain. Keep the physical and mental health at its best. Overwork, loss of sleep, and lack of fresh air may cause relapses, but perseverance will overcome these difficulties. A boy who will overcome the habit of stammering can be depended on to overcome other difficulties.

TOPICS FOR INVESTIGATION

1. Why do so many more boys than girls develop the habit of stuttering?
2. Make a special study of each individual case of stuttering among your pupils.
3. Outline a definite program for each individual stutterer under your care, and note the results of your work, day by day.
4. Show how imitation sometimes causes stuttering among children. Why does imitation seem to play such an important part in starting children to stutter?
5. Why is stuttering called a disease?
6. Does stuttering indicate any mental weakness?
7. How much time will be required in ordinary cases of stuttering to break up the habit?

SELECTED REFERENCES

BELL, A. M. *Principles of Speech and Dictionary of Sounds, including Directions and Exercises for the Cure of Stammering, etc.* Washington, 1900. 296 pp., illus.

CONRADI, E. *Speech Defects and Intellectual Progress.* Journal Educational Psychology, v. 3, pp. 35–38.

FREEMAN, VIRGINIA W. *The Proposed Movement for Treating Stammering in the Public Schools.* Educ. Bi-monthly, June, 1910.

HARTWELL, E. M. *Stuttering.* Boston School Document No. 8, 1894, pp. 69–97.

LEWIS, G. A. *Home Cure for Stammerers.* Detroit, 1907. 415 pp., illus.

SCRIPTURE, E. W. *Treatment of Stuttering.* Journal Amer. Medical Association, April 22, 1911, pp. 1168–1171.

SCRIPTURE, E. W. *The Cause and Treatment of Defective Mutation of the Voice.* Journal Amer. Medical Association, Feb. 11, 1911, p. 420.

SCRIPTURE, E. W. *Speech Defects and Voice Culture.* New York. 8 pp.

SCRIPTURE, E. W. *Stuttering and Lisping.* New York, 1912. 250 pp., illus.

CHAPTER XIX

FATIGUE

Normal Fatigue is Healthful. — At the beginning of this chapter, I wish to say as forcibly as I can that normal fatigue is evidence of healthful activity, and those who read herein expecting to find excuses for laziness will save time by stopping at this point.

Fewer teachers injure themselves and their students by overwork than by dawdling, giving up to useless worry, or by working in bad air and in unhygienic clothing. Work is healthful, idleness is positively unhealthful. Work is energizing, idleness is weakening. Work enlarges and vitalizes, idleness narrows and deadens. Normal fatigue is a necessary concomitant to good health and proper development. This truth ought to be taught to all school children and should be remembered by all who are striving to be of the most service to mankind. He who does not regularly and frequently experience a sense of bodily fatigue brought on by an actual tax on his physical powers cannot hope to develop nor to maintain that physical stamina which is the substratum for all vigorous and sane activity. He who never puts his mental powers to regular and severe tests, even to the point of sensible fatigue, cannot hope to acquire that grip of mental endurance and initiative characteristic of the highest type of manhood. The first lesson this chapter has to teach, then, is this: Normal fatigue induced by legitimate toil, both mental and physical, is sensible evidence that we have used our powers in line with the demands of the laws of health. For by use the tissues are not only renewed and rejuvenated, but they are thereby

strengthened and trained to purposeful behavior. "He only seems to me to live, and to make proper use of life," says Sallust, "who sets himself to the performance of a severe task." But if normal fatigue induced by worthy activity is evidence of healthful living, that abnormal and withering weariness due to persistent overwork is evidence of sinful living. The most precious force in the world is that generated in the human brain and muscle. He who wastes it, and teaches others to do so, sins against all for which human energy and vigor stand.

With the hope and desire of giving no excuse in what follows in this chapter for lazy, listless, or dawdling work, either in the schoolroom or out of it, let the reader now direct his attention to some of the intricate problems of fatigue, not with the assurance that he can settle them, but with the hope, at least, that he may gain some better understanding of what fatigue means, and in so doing prepare himself for a better adjustment to his students and a wiser use of his own powers. The sanest and wisest man is he who has the power to see what is best to do under the conditions he is called to meet, and has the physical and moral strength to do it. In the light of this discussion of fatigue, it is not out of place to consider briefly the hygiene of examinations, especially those affecting young girls of high school and college age.

Study is Healthful, Worry is Wasteful. — In general, it may be said, studious life is a healthful life, if those who engage in such activity are furnished proper conditions in which to do their work, and are encouraged to maintain a proper balance between work and recreation. A student's life of necessity must be shielded from dissipation, and even from excitement and irregularity. The whole content of a modern curriculum emphasizes the value of worthy behavior and incites the student to strive for its attainment. This result of our school work is of great importance, and all too frequently is neglected in discussions of relative values.

Nervousness and Examinations. — It is claimed by many teachers that, generally speaking, girls are more conscientious about their school work than boys are, and therefore they are more likely to overwork than are boys. Be this as it may, and I am inclined to believe it true to a certain degree and in certain cases, yet it seems more than probable that what is sometimes interpreted as legitimate work is more or less useless anxiety and wasteful worry. This general nervousness of girls in the presence of intellectual tasks often exhibits itself as lack of inhibition and concentration rather than as a superabundance of conscientiousness. Such a nervous diathesis as is here suggested is often more marked in the earlier phases of adolescent girlhood than in those characteristic of the more advanced stages of development seen in college women. Set periods for severe tests are likely to serve as stimuli for much worthless and indeed wasteful expenditure of energy. It is my observation that girls worry more about the outcome of an expected examination than boys do. For this reason, if for no others, it seems to me that better educational growth and a great saving of energy can often be attained by focusing attention and emphasis upon the daily work of the term and insisting that the mark of proficiency for the term's work depends more upon carefully prepared lessons than upon the results of any final examinations. Such procedure will put the emphasis upon a steady regular pull, and will eliminate, as far as possible, undue excitement and useless worry. In addition this regular daily demand will afford the best of training in meeting responsibilities with no loss of reserve energy. In other words, it will habituate students to a regular life and give a training in inhibition and steadiness which will be a great service to them in their future lives.

It is, of course, a valuable thing to be able to meet the demands of an examination; to gather up one's whole mental strength and equipment and put them to a severe and purpose-

ful test. But the ability to do this should grow directly out of the daily work of the classroom, and will do so if the teacher is alive to the importance of her work and be not overburdened with numbers. Provision ought to be made, if possible, at each recitation period for a short, direct, and searching oral examination on the subject in hand, or that just passed over.

Worry over Examinations. — Girls are not likely to overwork if they can be prevented from wasting their energy in worry. Personal experience with a number of young women who worried themselves into neurasthenia and almost incipient insanity has made me feel that long, set examinations are often far more serious with them than with boys. The danger of overpressure through examinations is especially significant in the upper grammar grades and in the high school period, when growth is rapid and when the intellectual and emotional life are somewhat loosely joined. The examination should not be abolished, but it should be so ordered and conducted as to furnish no incentive for wasteful worry or disturbing anxiety. School authorities should have more faith in the judgment of teachers, and teachers should be given smaller classes, in order that the daily progress of each student could be determined through the medium of recitations and free discussions. Huxley once remarked that where systems of examinations are all dominant, pupils " work to pass, not to know, and outraged science takes her revenge. They do pass, and they don't know."

Fatigue Products. — When a muscle contracts, certain changes take place in its tissues. Certain chemical products are thus formed, and are known as fatigue products. The nerve fiber, which carries the stimulus to the muscle, seems not to suffer from fatigue. Fatigue has to do with the motor centers, or brain cells, and the muscles. Ordinarily the active muscle does not lose its power as quickly as the nerve centers involved, and hence fatigue is first noticeable as a failure of the nerve centers to control the movements. The reflex cen-

ters, such, for example, as those controlling breathing, walking, etc., are less subject to fatigue than the higher centers, such as those having to do with attention, reasoning, and the other higher mental powers. The fatigue products produced in both muscle and nerve matter are not completely understood. They are toxic when thrown into the circulation; and if they accumulate faster than they can be eliminated by the lungs, skin, and kidneys, they will, in a way, poison all parts of the body. This poisoning makes us feel fatigued. In other words, when we feel sensibly tired, we are, to a certain degree, poisoned by the waste products of our own tissues.

Symptoms of Fatigue due to Toxic Products. — If the blood from a fatigued person could be thrown into the tissues of one who is thoroughly rested, it would induce in the latter a feeling of fatigue, due to the poisons accumulated in the blood so introduced. This experiment has been tried on dogs, but not on human subjects, so far as I know. There is no doubt that similar results would follow if the experiment could be made on human beings without danger.

Weichart, a German scientist, has recently announced that he has discovered an antitoxin with power to neutralize the toxin in fatigue products. He claims that relief from the feeling of fatigue can thus be brought about. Be this as it may, it is certain that if an individual has torn down a brain cell, or used up the energy-producing tissues in a muscle, his only real relief from the decreased ability thus produced will come through rest and a rebuilding of the tissues.

Symptoms of Fatigue associated with the Destruction of Energy-producing Tissues. — By virtue of the loss of central nervous energy the most evident symptoms are slowness of association and consequent loss of power to recall names or to fix or connect new experiences with old ones. There follows also lack of power to inhibit, more or less mental confusion, diminished power of attention, a consciousness of inability, a modified emotional tone, and general dullness.

Naturally these symptoms vary in degree of intensity in each individual, and are associated both with the destruction of the tissues and with the poisoning influence of fatigue products. In the lower grades it is not difficult for an observant teacher to see the difference between the responses of the children in the evening hours as compared with those in the morning, when minds and bodies are fresh and invigorated.

Fatigue and Posture. — If children get tired, they naturally assume awkward and, so to speak, crumpled-up postures. It is difficult to sit or stand erect when the muscles are not held taut by the regular and unconscious outflow of stimulus from the nerve centers.

Notice how limp an animal falls when struck a fatal blow. All nervous energy is thus withdrawn from the muscles; and what before was an unconscious tension is followed, for a time, by total relaxation. It requires much nervous energy to sit erect; and one could not easily find a more severe task than to sit in one posture for an hour. Hence children need much freedom in movement; and when they are tired, the recumbent posture is the one which will rest them most quickly. General fatigue has therefore a decided effect on posture, and in this way may be a real accessory to scoliosis and other irregularities. If our school furniture could be so ordered that all the children in the first five grades could assume a reclining position and totally relax for fifteen or twenty minutes during a long session, it would bring great relief to the children, and at the same time prevent much wasteful, desultory effort to work. It is well to remember, then, that when you are really fatigued, you are fatigued all over. Strenuous, long-continued, physical toil will poison the brain as well as the muscles; likewise long, continuous mental strain will poison the muscles, as well as the brain. You cannot hoe beans all day and do much philosophizing at night.

Normal Fatigue. — The fatigue which comes as the result of an ordinary day's work, mental or physical, is normal fatigue,

and under normal, healthful conditions will disappear after a night's sleep.

Fatigue becomes abnormal and pathological when a night's rest or a longer period does not bring relief. Then we are liable to become emotionally disturbed. We worry, become morbid, cross, and generally disagreeable. We imagine all sorts of difficulties portend, and in time, unless relief is found by long, enforced rest, abnormal mental symptoms appear.

There is such a thing as acquired inability to rest; so that it may become very difficult for one to prevent the waste of nervous energy through useless activity. Even in sleep an overwrought, nervous person jumps, twitches, and seems unable to relax completely. Americans are proverbially poor at resting. Herbert Spencer said we had a new disease, and called it *Americanitis.*

On the other hand, it is equally possible to acquire the habit of relaxation, and snatch moments for rest even during the daytime. If one can command enough self-control to lie down and relax instantly, a few minutes of such rest will do more to regain strength than all the tonics on the market. Indeed, the health of our people is menaced by resorting to stimulants to deaden the sense of fatigue, wrongly concluding that such concoctions relieve fatigue. They, in reality, merely blind one to the danger, and render him insensible to the warning that nature normally gives.

Methods of testing Fatigue. — Many methods have been devised for testing the fatigued condition of muscle and mind; but none have been found entirely reliable or complete. Disregarding further unanswered questions regarding muscular fatigue, let us ask the question, How shall we know for a certainty whether our pupils are really fatigued or whether they are merely lacking in application? It may be well to say, again, that there can be no natural tire of muscles which does not to a certain degree fatigue the brain, and that no brain fatigue can be induced which does not likewise fatigue the

muscles. But some work is chiefly physical and some predominatingly mental. Hence we can with some show of propriety separate them for purposes of discussion. Kraeplin attempted to determine the decrease in efficiency in a continued piece of work, and to regard this decrease as an index of fatigue. One series of experiments consisted in the addition of long columns of figures in order to note the number added in any five-minute period and the number of errors made. This method is only indirectly available for school children. Burgerstein undertook to find the best way to use an hour's time in arithmetical work. Ten minutes were used in multiplication and addition followed by five minutes' rest. It was found that while the amount of work done in the last quarters might equal that done in the first, the number of errors and corrections increased. Naturally such exercises are not usual in school work, and while the results obtained are suggestive, they cannot authoritatively determine the length of a work period, nor dictate the rest periods between. They do show, however, a mental confusion associated with fatigue.

Griesbach undertook to determine what effect a fatigued condition might exert on the discriminative power of the mind by testing the shortest distance between two points simultaneously touching the skin that would give a consciousness of two distinct impressions. He found, in general, that as fatigue increased, the compass points must be further separated. This test is helpful, but can only be used to any advantage by a trained person.

Schuyten undertook in his school at Antwerp to test the children by finding how correctly they could copy certain combinations of letters in a given time during various periods of the day. He found that more corrections and mistakes were made toward the close of the day, for the children could not, or did not, attend so carefully and did not concentrate so completely on their work.

Ebbinghaus took a selection of prose composition, dropped

out certain words, syllables, and letters here and there through the selection, and sought to find when and under what normal conditions the children could fill them in with fewest mistakes. The results obtained furnish no conclusive evidence that this method can be used to any direct advantage by the average teacher.

These experiments have been commented on because, in a way, they are the most important yet made, and have in general stimulated to other experiments of more promising value.

The plain truth of the matter is that at this time there are no known experimental tests for fatigue which can be satisfactorily used by teachers in the regular schoolrooms. The teacher must yet rely in the main upon common sense and careful and discriminative observation of her pupils. A thorough knowledge of the methods of testing for fatigue and some experience in making tests will, however, help the teacher to a more discriminating analysis of the mental and physical condition of her pupils in this respect. If they are inattentive and lacking in concentration, she may find the cause in bad air, an overheated room, uncongenial work, or possibly physical fatigue. But if she is keen to see back of appearances to the causes, she can read fatigue in expression, failure of response, bad order, or a score of other reflexes. Lack of interest in school work is often lack of brain energy. Under normal condition the work of the morning hours is done with a zest not seen in the afternoon. Certain subjects fatigue the mind more readily than others, and each subject has, to a certain degree, its individual fatigue index. Here, of course, the methods of presentation have largely to do with attention or the lack of it. In general, a good method calls forth the highest quality of concentration, attention, or discrimination, and hence would, in general, be more fatiguing than thoughtless, scattering work. As skill to do in any line increases, general fatigue lessens for a given amount of time. It is tremendously hard work to learn to ride a bicycle, translate Latin poetry,

or write an essay. But as skill develops less energy is needed, or perhaps it would be better to say less energy is wasted, and the work is done with less fatigue.

Winch has recently made extended investigations on mental fatigue in day-school children.[1] One group worked arithmetical problems early in the morning, the other late in the afternoon. The difference in improvability shown by the early and late working groups is taken as the measure of fatigue, and its effects toward the end of the day.

His conclusions may be stated, briefly, as follows: (1) Boys and girls between six and seven years of age get very little, if any, value from arithmetical work done late in the afternoon. (2) A comparable group, doing their work early in the morning, gained above twelve per cent in ability to handle such work. (3) Two groups of children, about eleven years of age, one working in the early morning and the other in the late afternoon, both showed gains, the late workers eight per cent and the early workers eleven per cent. (4) Two comparable groups from a boys' school — boys about thirteen years of age showed very little difference in their improvement, the early workers having a slight advantage.

The results of the whole experiment seem to show that mental work involving reasoning of this sort appears to be less and less affected by fatigue engendered by the school day as children increase in age and mental capacity. For the older and more proficient children the fatigue effects, thus observable, were very small indeed.

TOPICS FOR STUDY

1. What times of the school day do you find your pupils most studious? Why?

2. How much inattention in your school is due, directly and indirectly, to fatigue? How much to lack of clearly directed work?

[1] See *British Journal of Psychology*, Vol. 4, pp. 317–341.

and earnest effort on the part of every student. He who does not learn to study seriously and energetically cannot acquire his full measure of power. Other things equal, he gets most from his school work who in early school life develops the power of concentration and learns to relish the challenge of his keenest endeavors. I hold it true, therefore, that no teacher is teaching in an hygienic way who does not through every possible and legitimate effort habitually call forth strong, robust mental toil from her pupils. A lazy, indolent school life cannot be healthful under any conditions.

Teach Children how to Study. — Children need to be taught how to study, and they must be shielded in every way from acquiring habits of desultory work. Teachers are constantly saying that their pupils dawdle, work aimlessly and with divided minds. This is as harmful to healthful mental development as a corresponding spiritless physical exercise is for fullness of bodily health and growth. But what can be done to stop this evil habit of desultory studying in school, or, better, what can be done to prevent its development? Without presuming to be able to answer this question satisfactorily to all, the following suggestions are offered with the hope that they will at least aid some teachers: —

(*a*) Make out a daily program in which each student will find a specific time schedule for study as well as for recitation. This program ought to be in plain view of all the students and by the aid of the clock they can see just when they ought to have finished their preparation for each lesson. When the time set apart for the study of one lesson has passed, all who are not reciting ought to be trained to go immediately to the preparation of the next subject in order. In other words, a definitely stated time for the study of each lesson, and habitual preparation for it at this time, will do much to eliminate purposeless work. By this means the teacher will know how much time has been devoted to each lesson, and can gauge the results accordingly. Such a program will utilize the tend-

ency to a time habit, and, best of all, will teach children how to save time through concentration and businesslike procedure.

(*b*) At stated times and in the different subjects utilize the period set for the recitation for taking up the next lesson and studying it *with* the class. This will enable the teacher to select out in one-two-three order the essentials of a lesson and then to teach the children how to lay hold on these in a positive way. It will enable her to "speed them up" in their work by showing them how much can be done in a short time. Listless work is death to good habits of study, as well as to normal mental vigor.

(*c*) Assign lessons with great care and with a full understanding of the subject matter involved and the probable difficulties likely to arise. This will necessitate careful preparation on the part of the teacher with reference to lesson arrangements. I believe I can tell a good teacher as readily through her lesson assignments as through her work during a recitation. A clear, specific, definitely assigned lesson helps pupils mightily in their preparation of it. When a teacher takes a minute or two at the close of a recitation to say, "In the next lesson there are certain things of special importance, which I am anxious to have you get. Give attention, and I'll point them out," then I know she is much more likely to get work done than one who says, "For the next lesson take to page 51." But more important still, she is developing power to seek for essentials. With these points clearly in mind, the teacher in assigning a lesson does so with a full knowledge of the time set in which to get it, and she will be less likely to transgress in length of lessons.

(*d*) Having assigned a lesson in this definite and conscientious way, then let the teacher hold her pupils responsible for the lesson. Nothing is more weakening and fruitful of desultory work in school than the failure of the teacher to exact of her pupils completion of all tasks which have been wisely and judiciously assigned. There is such a thing as a

habit of success, which will carry a pupil over many difficulties. A weakened and irresolute will results from repeated failure to meet the work of life as it comes. It is distinctly unhygienic to both body and soul to acquire a habit of dawdling.

Evils and Good of Home Study. — The pros and cons of home study have been discussed much of late both inside and outside the teaching profession. The general conclusion seems to favor home study for the higher grammar grades when it is wisely directed by the teacher and given in the nature of drill work rather than in advanced work. For students of secondary schools there seems to be no good reason why, with favorable conditions, they cannot do from a third to a half of their actual study work at home. But in both cases individual needs and individual conditions must be considered. Some homes are favorable for home study, others offer many hindrances. Some states in our country have enacted laws against home study for all children below the high school period. Some European countries, notably Switzerland, have taken the same action. The general testimony of our teachers working under these laws is to the effect that there has been less loss than anticipated. The truth of the whole matter is that if children of the grammar grades work diligently during school hours, there is generally little need for them to spend much time in home study in order to do the work demanded by the curriculum. Therefore, it is in every way a vital problem to teach children how to study and hold them to their highest efforts during the time school is in session.

Time needed for Recreation. — Each child has a right to sufficient time for recreation, and for voluntary general reading, and the physical nature of the child will demand such recreation, or it will even up by relaxed and dawdling efforts in things mental during school hours.

"The rôle and significance of hygiene for learning," says Dr. Book in his excellent study of the *Psychology of Skill*, "can hardly be over-

FIG. 47. — "Little Mothers." A scene from a recreation center, New York City. (Courtesy of Mr. C. B. J. Snyder.)

emphasized. It was found in this study that the number, length, succession, and seriousness of the irregular lapses in spontaneous attention and effort that occurred throughout the course of a test depended not alone upon the difficulty of the work, but more upon the hygienic condition of the nervous system and of the body of the learner at the time of the test. It was also found that the fluctuations in efficiency which occurred from day to day meant variations in the general mental and bodily conditions of the learner, that the easiest way to regulate and control them was by an improvement in the learner's general neural tone induced by sleep, rest, exercise, food, change of attitude or mood, by the selection of more favorable weather conditions, or by anything else that would improve his hygienic condition. It was found, further, that these daily lapses in attention and effort were responsible for the longer irregular lapses at the 'breathing places' in the curves. These facts taken with the following, namely, that the learners could do nothing directly (*i.e.* by sheer act of will) to control the fluctuations in attention and effort; that the forward steps in the learning were made quite unconsciously, the organism adapting itself to the conditions presented with little help from consciousness; the new adaptations were made only during a good period and on a day when attention and effort could be spontaneously and vigorously applied to the work — these facts indicate clearly the significance of hygiene for learning and the particular rôle it plays. It is not what the learner would like to do, but what his mental and physical condition at the time of study or practice will let him do, that is important for determining his progress. The process of learning typewriting is something like mowing a field. The farmer takes out his machine to cut his grass. He can only keep his machine in good condition and vigorously apply it to the work; the machine does all the rest. It does its own work in its own way. How well it works depends upon the nature and condition of the machine. So with a learner in typewriting; he begins to learn to use the typewriter. How well he does the work, how rapidly he improves, depends, (1) upon how strenuously he keeps himself applied to the task, (2) upon the learner, the mental and physical condition of his organism. He must keep himself in perfect condition and strenuously applied to the work; the organism does the rest. He needs but to consciously lay hold of, and make proper use of, the adaptations that are unconsciously fallen into, the habits and associations formed. All this suggests that if one wants to improve at the most rapid rate, he must work when he can feel good and succeed, then lounge and wait until it is again profitable to work. It is when all the conditions are favorable that the forward steps or new adaptations in learning are made. Whether the older associations are at such a time also more

rapidly perfected or whether monotonous practice will answer well as stimulating their growth, we cannot say."[1]

Impressions and Expression. — Impressions of the proper sort should precede and guide expression. In the beginning of the child's life, racially fixed reflex centers are the sources from which flow the expressions, which immediately start the impressions, and *pari passu* with these, consciousness is developed. Later and in a more or less definite order instinctive tendencies assert themselves and these, when properly interpreted, represent long-repeated racial experiences. These instincts as they arise prompt to their characteristic expressions, and, to the wise teacher, become the sign posts to guide her in her work of adjustment. The desire to play is such an instinct, and points to methods and materials which the teacher cannot neglect if she would deal with child life economically and with wholesome effect. In other words, and in a more general fashion, that teacher who takes advantage of the hints which instinctive desires propose, under normal conditions, will most nearly meet the demands of mental hygiene. Hence things before words; experience before elaboration; language before grammar; a need for accuracy in number relations before arithmetic; direct contact with the conspicuous features of the earth's surface before geography; something definite to say before undertaking to write a composition; an idea of the form of the letters before beginning to write; a clear impression of the form and parts of a word before spelling; as distinct a notion as possible of the pronunciation before trying to speak a word; finally, "impression before expression." This is a fundamental law in mental assimilation and must be followed, else a sort of physical overfeeding with its accompanying disquiet will inevitably result; for mental diges-

[1] See *The Psychology of Skill, with Special Reference to its Acquisition in Typewriting*, William F. Book, University of Montana Publications, Bulletin No. 53, pp. 180–181.

tion, just as physical digestion, depends on a proper and timely food supply.

Value of Expression. — Expression amplifies, corrects, and vitalizes impressions. Hence it is unhygienic from the point of view of sanity to undertake to divorce expression from impression. Instinct urges us to express, and all learning should find some natural, immediate, and laudable expression. Having felt the need for power over the multiplication table and having attained to this power, it is the duty of the teacher to apply it to the solution of problems related to the child's experience. There is no problem involved if I ask a child to multiply 283 by 57. These figures stand for nothing, and to the child they mean nothing. But if he wishes to find out how many apples there are in 283 baskets, each basket containing 57 apples, then he will realize that power to perform this operation will help him to solve quickly this problem. Problems are mental things, and figuring is merely a means of quickly getting accurate solutions. The matter contained in our daily lessons can be made significant and truly educative only when it is related and put to use. Interest is an emotional state arising when mental assimilation is taking place, when the subjective and the objective are wrought into unity. In other words, it is the expression of satisfaction with the mental bill of fare, and of a faith in its food value. Action, or expression, is the fundamental purpose of mind. For my part I can see very little purpose in mental life save as it guides, directs, and stimulates in the various activities of life. Mind has little meaning apart from its effect on the behavior. It therefore follows that that mind which has been organized about worthy expression in this larger sense is the mind most normally and thoroughly educated. Dr. Lincoln expressed this general idea with force and appropriateness when he said: "It is worth hours, nay years, of reflection for the teacher to get an insight into the principle *that action is on a higher plane than thought.* Not mechanical unconscious reflex or uncon-

sidered action, but action based on correlative thought, is what is meant. Neither is muscular activity and skill what is meant, though the bodily accomplishments are of the highest importance. The principle to be recognized is that every one of our feelings and thoughts has its correlated outward expression, and that the laws of physiology, of mental health, and of character require the completion of thought or feeling by expression in action. And as that which completes is the higher, so action is higher than feeling or thought." [1]

Manual training, now so much talked about, may or may not meet the demands for this normal and educative activity. If it is dosed out as so much unrelated work to be accomplished, it may become as much a grind as the average lesson in grammar. If it comes as an opportunity for the boy to express a desire or thought and thereby correct and complete his thinking in a given direction, then it is of peculiar educational value.

In this connection it may not be tedious to say that because life's demands are becoming increasingly complex, mental degeneracy is increasingly common, and in part results from overstimulations without correlative and significant expressions. Max Nordau's hysterical outcry some years since had sufficient elements of truth in it to afford a warning.[2]

Dangers of Overstimulation and Overcrowding. — Mental overstimulation results in loss of power to assimilate, and hence in functional disturbances which produce a feeling of revulsion directly opposed to learning.

Much has been said of late concerning the overcrowding of the curriculum and the great number of subjects comprehended in it. There is a serious danger in this congestion, but the danger arises not so much from overwork, as from lack of time to digest what is offered. Learning ought to be received with a relish comparable to that which attends the eager satisfaction of bodily hunger. It is as natural for the

[1] See *Sanity of Mind*, p. 100, Dr. D. F. Lincoln.

[2] See *Degeneration*, Max Nordau.

FIG. 48. — In the cornfield. New York City Parental School. If this is good for bad boys, why wouldn't it be good for good boys?
(Courtesy of Mr. C. B. J. Snyder.)

healthy mind to seek satisfaction in knowledge and wisdom as it is for a healthy body to satisfy the cravings of hunger. If our school work were natural and real, and the mental nourishment offered were properly proportioned, wholesome, and nutritious, instead of much lassitude and lack of appetite for it, there would be an eagerness and a hankering after it not often seen. A stuffed body gets bulky out of all proportions to the demands of usefulness. Muscle, not fat, has transformed the world. A mind fed as if it were to be sent to market totters under its own load. There is no power, no impetuosity, no initiative, no enthusiasm when learning is forced and given every thirty minutes in allopathic doses. Under such pressure nature develops a resistant not far removed from nausea.

The danger from a crowded curriculum, then, as it seems to me, is not primarily that of too much work, but of mental revulsion. The more the mind works under the stimulus of interest, and within the rather wide boundaries of endurance, it is gaining in power to accomplish and is in no danger of revolting. But when learning is divorced from interest, and especially when it becomes actively associated with distaste and repugnance, then mental health is endangered and the moral life is dulled.

The crowded program can be handled without killing interest and without benumbing all the centers of spontaneity, if books and subject matter are used according to the demands of normal child life. No sort of grind will at first recommend learning. But contact with real things in a vitalizing way, and the use of books to suggest and guide in observation, and to connect up the materials of experience, are, under wholesome conditions, never distasteful. There is nothing more deadening to the average child mind, however, than to set him to work on a lesson with no hint or suggestion of what he may expect or what possible relation such a lesson will bear to his needs or desires.

What Dr. Chittenden has said in reference to our physical food supply ought to give us a hint with reference to mental diatetics. He says we can "diminish the amount of our food one half with no detriment to health." More perfect assimilation of things mental will give better mental health than any stuffing process yet devised.

But it must be remembered that the brain is a series of highly specialized centers, and that it needs a variety of stimuli to insure that functional growth its organization calls for. Hence there is need for variety in the curriculum, though this does not mean daily dissipation. This remark ought to suggest to all teachers this question: How can I arrange a program which will include the materials of the curriculum, and yet safeguard the children against sudden changes and regular dosage in opposition to their varying mental appetites? There is little doubt that our programs are too rigidly adhered to at times, and that we fear to take advantage of mental inertia in given subjects. But on the other hand freedom in the hands of thoughtless teachers is license to introduce what may lead to even more serious dissipation.

Premature Demands on the Nervous System. — When those parts of the nervous system involved in the demands made are still undeveloped, or even underdeveloped, there is danger of brain fatigue or, what is still more likely, inability to function properly, and hence erroneous connections are made and vital interest impossible. The power to reason is primarily the ability to recognize likenesses and differences, and to handle these elements abstractly. Reasoning depends on association, and association depends on functional connections between the various cortical centers. If these association fibers are not medullated or insulated by their proper sheath, they cannot function, and hence under such conditions, proper connections between ideas are impossible. If a limited number of connections have been made, they cannot economically take charge of the work that normally belongs to those

still undeveloped. There is danger, then, that the teacher, by reason of her well-organized mind, will fail to recognize these gaps in brain function and attempt to exact demands wholly beyond the power of the children to meet. The *hygienic use* of the curriculum demands a sympathetic insight into the functional workings of the brain, and at the same time a skill in handling the material so as to select from it those parts which will fit in with the power to receive and assimilate. Precocity is frequently a dangerous symptom, for it means that general powers are called on to do specialized work, and habits are thus fixed which preclude at a later period short cuts and greater economy of effort. It is a recognized principle of great importance to mental welfare that the fundamental and coarser movements of any organ or series of organs are those that develop first, and that the finer or accessory parts are comparatively late in reaching their maximum powers. Many normal children at six years of age cannot lift their fingers from a table separately and in order; but these same children may have a good control of the larger movements of the arms. It would certainly be unjustifiable to set finger exercises on a piano for such children, or to attempt to have them do with their arms what their fingers later will be better adapted to do. Children must learn to walk before they can dance, jabber before they can talk, become acquainted with their own desires before they can appreciate the desires of others, and see in the large before they gain power to analyze.

When children are called on by a teacher to get from a printed page what they have not in some fashion and in essential elements gained through experience, that teacher may certainly prepare for disappointment. But the harm done would be slight if it merely stopped at disappointment to the teacher. The children are puzzled, they learn to balk, and in time lessons become distasteful and habitually tedious.

Follow the Order of Mental Development. — Consideration of the sins committed against children in this way has

led some teachers to extreme views. One says in substance: The present school system seems to be arranged without regard to the order of mental development, but is based on accident rather than on reason. A thorough knowledge of child mind points to the conclusion that reading, writing, and arithmetic do not properly belong to the early years of child life. They all involve more than a child under ten years of age ought to be asked to do.[1]

It is a common observation to note how easily and quickly children pick up a foreign language, and how difficult it is for an adult. Children are naturally susceptible to spoken language, and their brains are peculiarly ready to fasten upon words, phrases, and forms.

Experiment in the Philippines. — Our government is at this time concerned with one of the greatest experiments in the teaching of a modern language the world has ever seen. The school children of the Philippine Islands have been set the task of learning to do all of their school work in a foreign language, and in three years' time under very unfavorable conditions they acquire a fair command of our tongue and at the same time learn to calculate a little, and to read and write. They learn something of geography, nature study, agriculture, manual work, and incidentally many other things along with the language. It would be utterly impossible to make the same progress with ignorant adults. The secret of the success with these children lies in the fact that they are set to do what their brains are prepared to handle economically.

Proper Treatment of Backward Children. — There are in all city systems of schools, and not infrequently in country schools, children who, through inheritance, defective nourishment, or the lingering effects of disease, are not capable of keeping pace, at least for a time, with the more favored members of the class. These children are not only likely to suffer from

[1] See *Should a Child under Ten learn to Read and Write?* G. W. T. Patrick. Pop. Sci. Mo., Vol. 54, pp. 382–392.

faulty classification, but they are frequently *hindrances to* the normal progress of their classmates because of the fact that they demand more than their due proportion of the teacher's time. Many such children are not dunces, and may, with proper care, develop into worthy and useful members of society. They are not capable of acquiring a mastery of the fundamentals requisite for every self-helpful citizen. The school organization is at fault if children are not furnished the opportunities and the time for the work best suited to their development and future needs. The teacher is at fault who does not daily attempt to give them the mental rations their progress demands.

Special Classes. — In large city systems of education in this country, and particularly in Germany, special classes or auxiliary schools have been organized and equipped for the care of these children. Teachers are trained and selected for this special work, and as a result better adjustments are obtained all around. In country schools, or small city systems, flexible grading and a greater amount of individual instruction seem to be the only courses open to the teacher in dealing with these belated and slow growers. Here tact is required; and most of all definite plans, to be entered upon with the understanding and consent of the parents, are needed. When a course of this sort is marked out, which has for its aims better adjustment, there is no need to call it an easier course, a shorter course, or a course designed for weaklings. It simply is a better course for these children, and should be as dignified and honorable as any other course of work offered. It is essential that such work differ in kind as in quality, but it must be guarded from any possible suggestion of inferiority. (See Chap. XXI.)

Saving through Habits. — It is good hygiene to turn over to the spinal cord or some lower center much of the mechanical and oft-repeated work of life, so that the higher centers may devote their energies to those activities demanding conscious guidance. After conscious training in writing, walking, read-

ing, speaking, spelling, figuring, and many other common *requirements, the child should be trained to do them by the* force of habit, or reflexly. In later life this will save much effort and brain waste. Hence it is a wise thing for teachers in primary grades to demand constant accuracy in speech, in spelling, and in all those things wherein mere memory is at stake, or habitual action is demanded. The spinal cord can be relied on for accuracy, if accuracy be required in learning and in drill work. To this end spelling, *e.g.*, should be so taught as to permit of as few mistakes as possible. It is a safe and hygienic rule never to ask a child to spell at a word if we have good reason to believe he will misspell it. Each error made signalizes lost ground. But pure drill work, if continued for many minutes, will end in aversion, and gains already made will be lost. Keen and enlightened judgment on the part of the teacher is the price of prudent drill work. Investigations have shown that spelling ought to be learned incidentally for the most part. Much drill is a waste of time.

The Hygiene of a Daily Program. — The making of a daily program of studies offers large opportunities to utilize to the best advantage the varying powers of mind during the school session. Generally speaking, those children who come to school from homes adjusted to the needs of child life, who have slept ten hours in well-ventilated bedrooms, who have been fed with nourishing food, and who have not tired themselves by too much home labor are freshest and most receptive in the early school hours. It is economy, then, to utilize this abundant energy and its characteristic interest on those subjects which are generally the most difficult to teach. But alternation between formal and content studies will also save time and brain waste. Obviously, the length of recitation periods should vary with the age of the pupils and the subjects studied. Much experimental investigation has been made in the past quarter century or so, to determine as accurately as possible rules to guide in the length of the recitations in the

various grades. It is not possible to get results which approximate absolute accuracy, for conditions are complicated and variable. Besides, the personality of the teacher and her skill in handling a subject have much to do with relative values in the length of recitation periods. Close attention to the subject in hand is essential in all recitations, and, as such a condition rather quickly induces fatigue, short periods are necessary for primary classes, with rest periods intervening. For the higher grades the time should vary with the subject, the time of day, the previous periods of rest or work, and the general mental vigor of the class. Some teachers can make a short period count for much, others move slowly.

Attention is subject to rhythmic fluctuations, and must therefore find periods of comparative repose if it is to reach at any time beats of strong concentration. In a large class, where much unevenness of power is commonly found, it requires the highest kind of skill to handle a topic so as to bring the vital matter of the subject before all minds at the moment when attention is at its flood tide, and then to catch the swing of it for further assaults.

Hygiene of Physical Education. — In the work of physical education it is unhygienic to cause children to develop out of proportion to the demands of normal and usual living. Athletes who have through long-continued training developed a lot of muscles not usually needed, or a heart capacity beyond the demands of customary living, are thereby endangered through the onset of natural degeneration when they settle into a normal or a probable form of life which makes less strenuous demands on the circulation. Physical education will fail of its purpose if it does not adjust its efforts to preparing the body to do its work without danger of degeneration. It is probable that most people could by early and systematic training develop the muscles to move their ears. But it surely would be a waste of time, and it would also offer opportunity for degeneration as soon as such useless efforts ceased.

There is little danger in ordinary training and play, but specialized athletics of a more strenuous sort does introduce dangers of serious moment. Good teaching in physical education intends to develop those powers of body needed to meet successfully the usual and fundamental demands of life. Specialization here, especially in early life, with normal children proceeds on the wrong principle.

Hygiene of the Voice. — The proper use of the speaking voice is an accomplishment by no means of minor importance, both as to the quality of tone, and the ease and force with which it may deliver the meaning involved. But there is an hygienic phase to vocal training of much importance. The delicate tissues of the pharynx are easily fatigued, and sore throat and harshness frequently follow a forced and erroneous use of the voice. Teachers who have not learned to speak with ease and with pure tones suffer much inconvenience, and they are sometimes afflicted with serious throat troubles. A child who is taught to speak slowly, distinctly, and with pure tone, not only gets a better hearing than one who speaks improperly and with an effort, but he likewise escapes throat troubles which lead to more serious disturbances. That teacher who understands how to train the speaking voice, in order to get good tone and good easy control, is working in the interests of health as well as for power in expression. A harsh, raspy voice is a serious handicap socially, spiritually, and hygienically.

SPECIAL TOPICS FOR INVESTIGATION

1. Is it true that orderly teaching and orderly learning are more hygienic than the opposite processes? Why?

2. Which is the more healthful and wholesome life, one spent in reading much and doing little, or one spent in little reading and much doing? Why?

3. Does the average school curriculum offer a well-balanced hygienic program of learning and doing?

4. It has been said that spelling is learned just as well incidentally

through reading and writing, without special drill, as with it. Find out if this conclusion is warranted.

5. At what stage in the development of a child can the various subjects of the elementary curriculum be introduced most economically?

6. Work out the proper length of recitation periods for your classes.

7. How much time should be taken daily for rest or recreation periods for each grade, under the conditions of your program?

8. Arrange your program, and assign your lessons so that they may all be prepared at school, in order to see if home work is really necessary for elementary pupils.

9. At what time of day and under what conditions can you commit to memory most readily?

10. What are the special dangers of precocity?

11. The physiological age *versus* the chronological age in the hygiene of instruction.

12. Do the average school programs give a well-balanced sensory development? Give good reasons for your answer.

13. Why do children learn to speak a foreign language more readily than adults do?

14. How is it that a teacher who speaks easily and distinctly, with a pleasant tone, may save her own health, and also, in an indirect way, that of her pupils?

SELECTED REFERENCES

BEAN, C. H. *The Curve of Forgetting*. New York, 1912. 45 pp.

BURNHAM, W. H. *A Contribution to the Hygiene of Teaching*. Pedagogical Seminary, v. 11, pp. 488–497.

BURNHAM, W. H. *The Hygiene of Drawing*. Pedagogical Seminary, v. 14, pp. 289–304.

BURNHAM, W. H. *Arithmetic and School Hygiene*. Pedagogical Seminary, v. 18, pp. 54–73. Bibliography.

DEARBORN, W. F. *The Psychology of Reading*. New York, 1906. 134 pp.

HUEY, E. B. *The Psychology and Pedagogy of Reading*. New York, 1908. 431 p.

KUHLMANN, F. A. *The Present Status of the Memory Investigation*. Psychological Bulletin, v. 5, pp. 285–293.

LEWIS, G. G. *Typical School Journeys*. London. 140 pp.

MACMILLAN, D. P. *Report of the Department of Child Study, Chicago Public Schools*, No. 4, pp. 11–16.

STARCH, D. *Experiments in Educational Psychology*. New York, 1911. 183 pp.

Psychological Clinic. Philadelphia. Monthly.

CHAPTER XXI

THE CARE OF EXCEPTIONAL CHILDREN

History of the Movement for the Care of Exceptional Children. — Provision for exceptional children began in the public schools of Halle, Saxony, more than fifty years ago. The first so-called Hilfsschule (auxiliary school) consisted of a special class where seventeen backward children were segregated for a possible two hours of special instruction in 1859.

Chemnitz followed with the establishment of her first auxiliary class in 1860. In 1864 a small book of forty-three pages was published by Stötzner, with the title *On Schools for Children of Deficient Capacity.* In this book there was an urgent appeal to all authorities of the larger cities of Germany for the establishment of auxiliary schools for the special care of those who could not profit much from regular school work, and who later would become burdensome to the communities. Slowly the ideas that Stötzner advocated began to bear fruit, and by the beginning of this century quite a number of the larger cities had established such schools, or special classes, in which these children might find the kind and amount of instruction that they were obviously in need of. In our country, to meet similar needs and demands, special classes were formed, first in Cleveland in 1878, but the work in these classes had to do for the most part with those children who were troublesome to handle from the point of view of discipline. Chicago and other cities followed.

The Influence of Child Study on Provisions for Exceptional Children. — But during the last twenty years more has been found out about children than in the whole of the previous

century. As a result of these investigations into the mental and physical life of children, it has been found that great variations in their endowments exist. The problem of grading and classification for the sake of the individual, as well as for the sake of those who profit most when working in the social unit of a homogeneous class, has commanded and received much attention. Hence the demand has come to respect the rights of those children who, from one cause or another, are not able to make as rapid progress as the majority. In addition the social and educational significance of well-graded classes is better understood and more intelligently appreciated.

Problems of Classification. — The one question for discussion in this chapter is, how can we best handle those backward and retarded children who, while not up to the standard of the average public school, are yet dependent on the public schools for their educational equipment? It is obviously a duty to segregate such children, both for the sake of their own progress and for that of the more fortunate pupils. Kept in a class where progress is necessarily too rapid for them, or for one reason or another the work is not properly adjusted to their special needs, they not only lose confidence in their ability by reason of their failures, but they often become hopelessly confused and fail of clear apprehension of anything. The difficulties that teachers and school administrators have had to meet in dealing with them are not only those that arise in the classroom, but those which have to do with justice to parents and children. A child who does not keep up with his classes is a source of friction between parents and teachers, between teachers and principals, and often between teachers and school boards. The teacher cannot recommend promotion, for the child is not ready to profit by the work of the next higher grade; in fact has not profited much by the work he has already undertaken. There is a limit to the amount of individual help a teacher can give, for she must not, out of fairness to the majority, trespass on the time and energy due them. Hence the

backward child gets little in the regular classes, and even this little may not be in line with his just needs.

Special Names for Such Classes. — But parental objection has very frequently made it impossible for either the principal or superintendent to place the child in separate special classes. These classes are subject to names which offend the sensitiveness of parents. School children stigmatize such classes by calling them "schools for fools," "dunce schools," or "schools for lazy children." Even school authorities have had a hard time to find names for them, free from implied humiliation to parents, who often have no power to understand the weaknesses of their own children. Helping schools, misfit classes, ungraded classes, special classes, and many other quasi descriptive titles have been devised to forestall such criticisms. None of them has been entirely successful, as any school principal or superintendent who has undertaken to meet the needs will testify.

Problems relating to Such Classes. — Among the problems relating to such classes are the following: —

1. The need of specially prepared teachers for such children.
2. Some suggestions on the kind of school opportunities such children need.

1. **The Need of specially Prepared Teachers.** — It is manifestly neither wise nor diplomatic for a superintendent to undertake to segregate all backward children into special classes or separate schools until he has first satisfied himself that he can furnish them teachers who have had some special training that will enable them to deal with such children helpfully. Many attempts have been real failures because of this lack of foresight. One of the vital problems, then, in connection with this work is that of securing well-prepared teachers, who realize what these children need, and are given opportunity to work unhindered by a program mapped out for normal children.

Special Knowledge Needed. — But what sort of special knowledge should a teacher for such children possess? Without attempting to answer this question with complete satis-

faction to myself or to the reader, I wish to offer the following suggestions for consideration: —

Training in Abnormal Psychology Needed. — She ought to have a thorough training in normal and abnormal psychology. I make this statement, well aware of all that has been said *pro* and *con* on this question. I know the word psychology is one that has been on the lips of many teachers who have proclaimed its great significance, and who at the same time knew really nothing about it save textbook talk. This is not what I mean by training in psychology, for such in reality is training in books about psychology. To be thrown into the midst of a group of normal or subnormal children without some theories to guide one in the study of their mental powers and bodily infirmities would be of course unscientific and wasteful. And to enter a schoolroom with a completed scheme of mental life results usually in a disastrous attempt to make children conform to such a scheme. I mean, then, by a thorough training in psychology, a thorough training in the honest observation and analysis of mental and physical life as it actually exhibits itself in normal or subnormal children. Much classification at first will inevitably deprive the observer of power to see the truth, but classification is necessary. It ought to come, however, as the result of a desire to understand a real situation, guided but not hindered by the best classifications others have made of comparable phenomena. If an intelligent interpretation of individual mental life is necessary for the teacher of normal children, it is doubly so for those who train defective classes. Here the teacher counts for more, or at least is more essential to the progress of the child. Normal children learn much from mere hints and suggestions; backward children must have oft-repeated stimulus and guidance. The physical machinery of normal children runs smoothly or at least it offers little hindrance to mental progress; the backward child is nearly always handicapped by some functional disturbance. The psychology

of the subnormal is more intimately associated with the physiological, or at least is more obviously so related, than that of the normal child. Not only then must new methods of instruction be devised to meet the requirements of these children, but a new emphasis must be placed on the adjustment of body and mind. The fundamental instincts are here, as it were, segregated from those discriminating associations which normal mental life makes use of, and which often attract most attention in ordinary treatises on psychology.

Physical Impediments. — One who would understand the defective must learn at the outset what physical impedimenta are operative, and how these conditions can be ameliorated. The inability to see clearly and quickly may produce retardation. Imperfect hearing may, and often does, result in abnormal emotional response to all social situations. Adenoids may not only act as a primary cause for dwarfing various organs of the body, but may serve indirectly to produce general anæmia and physical weakness, and such conditions are not conducive to mental aptitude. Feeble circulation not only calls for special exercise, special clothing, and special care of the skin, but likewise foretells difficulties in attention, slowness in perception, lack of interest and general dullness in response to the appeals of educative agencies.

Diseased and fragile teeth may be either a cause or a product of poor nourishment, and poor nourishment, especially for the less active minds, quickly makes its presence known in weakened mental response. Furthermore, for one reason or another, the central nervous system may be dwarfed and stunted so that the more fundamental activities, relatively speaking, exist in undue proportion to those accessory powers active in higher mental response. Plainly, such children need to use what talents they have as the basis of their educational work, and only indirectly and incidentally should they be called on to undertake the intricate and minute affairs of mental life expected of the more highly endowed children.

The Need of Scientific Training. — A teacher for such children ought to be trained in methods of scientific mental measurements, and have the power to see the significance of such facts when once obtained. I cannot, for example, believe a teacher capable of handling understandingly such children if she does not know how to apply such tests as are furnished by the Binet-Simon scale, and of really seeing why these tests approximately measure the mental capacities of most children. While, on the whole, they are very simple, yet in general they seek for the central axis of mental life, and lay bare before a penetrating mind the fundamentals of psychic growth.

It is a simple thing to ask a child to tell the difference, for instance, between paper and cloth, but it is not so simple a thing to see by his answer that he has or has not the power to handle general notions and to express himself in abstract terms. It is an equally simple task to request a child to rearrange a rectangular card that has been cut diagonally into two triangles, but it requires a trained mind to understand what sort of mental processes a child must pass through before he can quickly and correctly execute the demand, and why he, in general, must be approximately five years old before he can do it easily and readily. The whole problem of the level of normality for any given age demands for its solution more than textbook information, and more than simple observation.

A New Sort of Treatment Required. — But interpretation and insight are only parts of the problem. Having found that the psychic life of a child is below the level of the normal child of the same age, the next, and perhaps a more serious, problem is to know what is best to do, or what really can be done, for his betterment. Here a new kind of pedagogics must be wrought out. We yet know only the barest outlines of it. Why is it, for example, that many defective children show unexpected talent and interest in music? An adequate

answer to this question must come from the larger genetic field. If we ask in what way and to what extent we can induce and accelerate growth through music, a still more complex situation meets us.

2. **Problems of Organization and Methods of Teaching.** — The next suggestion has to do with organization and administrative methods. How can our schools be organized to give relief to those children who, while not idiots, are still very slow in their development, many of whom give no hope for attaining any high degree of culture?

Ungraded Classes. — The so-called ungraded class for misfits has been one of the most generally used devices in our school organization to meet the needs of those who for one reason or another have been retarded, or for those who are able to make more rapid progress than the regular classes. The management of this class has usually fallen to the lot of a teacher selected from the regular corps, and the kind of work undertaken has depended, from week to week, on the needs of the children as indicated by the teachers from whom they came, and the demands of the grades the children are supposed to make. The work in these classes has, of necessity, been largely individual. The teacher may concentrate her efforts for one child to bring it up in arithmetic or grammar; for another she may give special attention to reading, geography, spelling, etc.; for still another her aim will be to awaken a real interest in school work through some unusual appeal. To those who merely need opportunity and general supervision, in order to gain time, she assigns larger tasks and sees that these are done thoroughly and with clear understanding.

A child may be dropped into such a class for a week, a month, or for no specified time, and it is expected that he will be transferred to a regular class as soon as, in the judgment of the teacher and principal, he can do better work with the stimulus of a class than when working as an individual.

The Difficulties with Ungraded Classes. — Such ungraded classes have helped many normal children who have either fallen behind or have shown that they are being held back by regular class work. But there has not come a great amount of help for those who, while not really feeble-minded, make slow and uncertain progress. There are several reasons why the ungraded class as here described will never meet the real needs of those whose minds are slow to perceive and still slower to appreciate the real meanings involved. For the most part, the methods of instruction used in such ungraded classes are too nearly patterned after those used in the regular classes. These retarded children need and demand a more natural education than teachers are prepared to give, or, for that matter, than the regular schools are equipped to give. The awakening and quickening of such minds must come through a real rationalizing experience. School life must be fashioned after the highest kind of real life into which such children are capable of entering.

Ungraded classes, in the sense I have used this term, have not been able properly to care for those children who are defective or feebly endowed. They need a different program and different conditions. This leads me to the next development in public school administration looking toward help for these children.

The Need of Open-air Schools. — Open-air schools, which are more fully discussed in Chapter XII, originated in the movement to provide during vacation for tuberculous and scrofulous children. These schools were at first vacation camps or forest schools, where the chief emphasis was placed on the improvement of the health of the children. Fresh air, free play, and nutritious food were at first the chief desiderata. Gradually some instruction in nature study, gardening, and drawing were introduced. Finally, it became evident that, under such conditions, sluggish children exhibited marked improvement. This has led to what are now more properly

called open-air schools for defectives. This movement is just beginning to take hold of our people, and there is now scarcely a day passing in which calls from some part of our country do not come for information concerning open-air schools. With too many it is attractive simply because it is something new. Others are seeking in a serious way for guidance. Here, as in the ungraded classes, proper classification and organization of work for subnormal children is still in a chaotic condition.

Special Buildings for Subnormal Classes. — I am persuaded that before any progress of a fundamental sort can be made, special buildings for subnormals must be constructed in the cities, and real segregation made mandatory. Before this can be done in any effective way, parents must be made to see that, while it may be distasteful for them to see their children placed in special classes, they can be better cared for there than elsewhere. Then, too, they must be made to understand that any school system is properly organized only when each child is so conditioned as to offer no hindrance to others, and at the same time to get what he himself is most in need of. We must organize and teach our schools so as to give to the great majority of normal children all the time and attention they need. Furthermore, it is essential that superintendents give better care to our brighter children than to the dullards. Any organization which will tend to hinder the rapid but normal progress of the brighter children is more at fault than one which does not give special help to the weaker pupils. The only way, then, is, as I have suggested, real segregation. How can this be done, with justice to all? The only way open, so far as I can see, is through expert psychological examination of the children. I have called attention to the Binet-Simon tests. These at present, with Dr. Goddard's modifications, seem to afford the best general mental yardstick which we now have at command. However, the general problem of mental measurement is now the central problem

of educational psychologists, and teachers for subnormal children ought to be in the thick of it. By and by we shall have more psychological clinics, and shall be able to measure mental life more satisfactorily, and have fuller knowledge of the conditions operating to hinder progress or to accelerate it.

TOPICS FOR FURTHER STUDY

1. In what ways can the public school teacher organize her instruction so as to give some individual help, each day, to those who are able to make more rapid progress than class instruction affords, and also to those who proceed more slowly than the class?

2. Study carefully the Binet-Simon method of testing children's natural ability. Make out, if possible, the fundamental reasons for each test proposed.

3. In what ways can you adapt the regular school curriculum so as to get better results for both the unusually capable child and the backward child?

4. Study carefully the physical development, well-being, and history of each backward child, in order to determine, as far as possible, whether the mental defect is due to inheritance, delayed development, or is the result of physical defect due to disease or accident.

5. Note in each case the particular weakness or defects exhibited, and devise methods to correct such defects. Knowing just what is needed is a necessary preparation for knowing what to do.

6. Make a study of the method of treatment of subnormal children in special schools for defectives.

SELECTED REFERENCES

AYERS, L. P. *The Binet-Simon Measuring Scale for Intelligence.* Psychological Clinic, Nov. 15, 1911, v. 5, pp. 187–196.

BARR, M. W. *Mental Defectives.* Philadelphia, 1910. 368 pp., illus.

BRECKINRIDGE, S., and ABBOTT, E. *The Delinquent Child and the Home.* New York, 1912. 355 pp.

DAWSON, G. E. *A Characterization of the Prevailing Defects in Backward Children.* Pedagogical Seminary, v. 16, pp. 429–436.

FERNALD, W. E. *Importance of the Early Discovery and Treatment of Defectives in Special Public School Classes.* Teacher, December, 1906, v. 10, pp. 291–299.

GODDARD, H. H. *Heredity and Feeble-mindedness.* Am. Breeders' Magazine, 1910, v. 1, pp. 165–178.

GODDARD, H. H. *Two Thousand Children tested by the Binet-Simon Measuring Scale for Intelligence.* Proc. N. E. A., 1911, pp. 870–878. Also Pedagogical Seminary, v. 18, pp. 232–259.

HUEY, E. B. *Backward and Feeble-minded Children.* Baltimore, 1912, 221 pp., illus.

LOVE, J. K. *The Deaf Child.* (See Chaps. 2, 4.) London, 1911. 192 pp.

MAENNEL, B. *Auxiliary Schools.* U. S. Bureau of Education, 1907. 137 pp.

VAN SICKLE, WITMER, and AYRES. *Provision for Exceptional Children in Public Schools.* U. S. Bureau of Education, 1911. 92 pp.

WALLIN, J. E. W. *A Practical Guide for the Administration of the Binet-Simon Scale for measuring Intelligence.* Psychological Clinic, December, 1911, v. 5, pp. 217–238.

CHAPTER XXII

MEDICAL INSPECTION OF SCHOOL CHILDREN[1]

Ideals of Proper Education. — The right sort of education enables a man to adjust himself, body and soul, with the least possible friction and for the greatest possible worthy service to any environment or circumstance in which he may find himself. While the aim of public education is most highly commendable, it is to be regretted that the mind has frequently been wrought upon at the expense of the body. Scientific investigations have proved beyond question the essential unity of mind and body. "Good health is at the bottom of all things good. The birth of wit is in good digestion; hope springs from a healthy circulation; and out of strong nerves comes success." Any system of education which graduates boys and girls physically unfit to perform the duties of life has, through its process, failed in its main purpose.

The Schools and Disease. — The unnatural life of the schoolroom affords excellent opportunity for the contraction and spread of disease. Most schoolrooms are crowded; many are poorly ventilated, lighted, and heated. Desks are unsuitable, forcing children to sit in cramped and unnatural positions. Children are forced to sit still when nature intended them to be running about. The children in an ordinary public school represent all classes and conditions of homes. Many are totally ignorant concerning the necessity and beauty of personal cleanliness. Especially in the lower grades, children are careless about coughing, sneezing, and expectorating — often expelling infective matter from the throat and nose. It is only

[1] The author has been aided in the preparation of this chapter by Mrs. Cora Sutton Castle, M.A.

recently that drinking fountains have been devised to displace the custom of fifty children using one cup. When we consider how careless most young children are concerning nasal and mouth discharges, we see the excellent opportunity for the transmission of germs when the same plaything and tools are used, as is the case to a large extent, in the primary grades. Children are confined in a schoolroom for five or six hours a day when much of that time should normally be spent in play.

FIG. 49.—A typical case of adenoids. 1, before removal; 2, after removal. (Courtesy of Cleveland Board of Education.)

Children are, moreover, susceptible to many diseases, and the schoolroom is preëminently a place, where disease germs have an opportunity to develop. To protect children from the dangers that in the nature of school life must be associated with it, it is necessary that every school should have a well-organized system of medical inspection.

Dr. G. W. Johnston says, "Wherever investigations have been made on a large scale, three things have been revealed:

"1. A surprising amount of ill health among school children, 60 per cent being defective to a greater or less degree.

"2. Though varying in degree from slight functional disturbances to actual illness, the same morbid conditions were found wherever and whenever investigations were made.

"3. The percentage of morbidity increased from grade to grade "[1]

Diseases of School Children. — Of all the diseases which make up the sum total of ill health among school children, defective vision and diseased teeth (see Chaps. XV and XVII) are the most common.

Adenoids. — Next to be considered, on account of frequency, are affections of the nose and throat. Dr. L. Emmett Holt, in his *Diseases of Infancy and Childhood*, says, "Adenoids are the source of more discomfort and the origin of more minor ailments than almost any other pathological condition of childhood." They occur most frequently in damp, changeable climates. Their first symptoms often follow an attack of measles, scarlet fever, or diphtheria. Rachitic children are oftener affected than others. Repeated head colds are more often a result than a cause of adenoids. They are most frequently associated with the constitutional condition known as *status lymphaticus* (swelling and increase of tissue in the lymph glands). Heredity has a marked influence. The pharynx, or throat proper, of a normal child is a delicate, moist pink with the tonsils just large enough to be seen, and the secretion sufficient to maintain the proper amount of moisture. The membranes are very sensitive to irritation In the case of an abnormal throat, there is much discharge, often not noticed because it is swallowed, and the tissues in the vault of the pharynx may increase so as to close the passage through the nose. Some of the most important symptoms of adenoids are a nasal voice, with inability to sound the consonants *m* and *n*, *b* and *d*; difficult breathing, especially when lying on the back, and at night. often amounting almost to asphyxia. This is probably the explanation of many of the

[1] *North American Review*, v. 182, pp. 829–839.

night terrors from which children suffer. Bloch lays great stress upon the association of mouth breathing with stuttering. "When the mouth breathing has persisted for a long time, certain changes are seen in the face, mouth, and chest. The

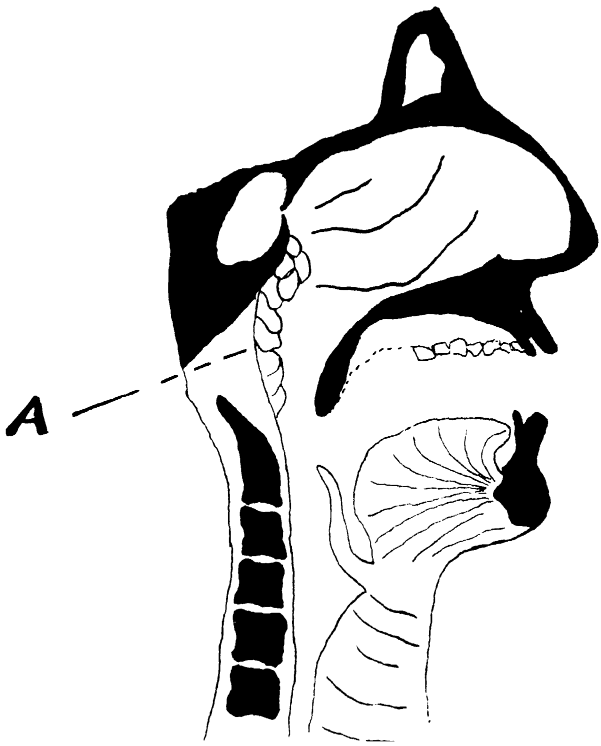


FIG. 50. — *A*, showing the location of adenoids.

expression is dull, heavy, and apathetic, due, in part, to the mouth being left continually open. The child becomes stupid looking, responds slowly to questions, and may be sullen and cross. The lips are thin, the nasal orifices small and pinched-in looking, the superior dental arch is narrowed, and the roof of the mouth is considerably raised. There is a marked change

in the shape of the chest, the 'pigeon breast' being the most common deformity."[1] In a large proportion of cases the hearing is impaired. This is due to the inflammation being extended along the eustachian tubes, the obstruction with mucus, or the closing of the orifices by pressure of the adenoids. Naturally, the senses of taste and smell are much affected; the breath is fetid. The general health is often impaired from loss of sleep and insufficient oxygen because of difficult breathing and confinement to the house on account of frequent colds and catarrh. There is often a marked anæmia. In severe cases of long standing children may be stunted in growth. Headaches are frequent; it is impossible to fix the attention for any length of time; forgetfulness, languor, depression, inability to study without discomfort, — these with partial deafness cause children with adenoids to be marked as somewhat mentally deficient.

Enlarged tonsils frequently accompany adenoids. They obstruct respiration, result in partial deafness, and being exposed to infections from the mouth and nose, they offer opportunities for the development of the germs of diphtheria and scarlet fever.

These symptoms do not all occur at one time. The growths may be small, and the symptoms not sufficiently alarming to cause parents to detect the trouble, or consult a physician. A medical inspector would understand the situation at once, and advise treatment or removal of the obstructing tissue.

A Case showing Effects of Adenoids. — The following history of a case of adenoid growth retarding a child's progress in school is worthy of careful consideration. The child in question is one in a family of four children of whom all except him were bright and intelligent. This child was a strong and well-grown boy for his age, but was apparently of a sluggish and stolid disposition. He was removed from the first grade as too immature to do the work, and from that time to his

[1] Osler's *Principles and Practice of Medicine*.

eleventh year he never made a single grade legitimately; he was usually promoted on trial, and then dragged along at the foot of his class. All together, he had lost two years by the time he reached the fifth grade; but he had completed the work of the fourth grade in so unsatisfactory a fashion that he was required to repeat a term's work in that grade. The complaint of the teachers was that the boy seemed immature, that he was unable to give attention, that he was dreamy and could not keep his mind on his work. Outside of school, the boy's behavior was about the same. He was slow and heavy in his movements, and though gifted with an unusually strong body, he did not play with the usual zest and activity of boys of his age. He had no initiative, but followed the lead of his companions. His parents were certain that the boy was not lacking in intellect, however, because his memory was good, and he showed no lack of ordinary intelligence, except his slowness of comprehension.

When the boy was eleven and a half years old his parents took him to a specialist for treatment. For the past five years he had had difficulty in breathing; he slept with his mouth open, and breathed through his mouth in the daytime except when corrected, and then his breathing through his nose was labored and painful. He had been treated variously for colds and catarrh, but nothing had helped him.

The specialist examined the boy and found an adenoid growth in his throat, just back of the nose, which obstructed his breathing. This was removed and found to be as large as a walnut. The boy was treated for some time and pronounced cured.

His parents, in hope that he might regain the place in school which he would have held had he gone straight ahead, secured for the boy a private teacher, who had known him a long time. An almost immediate change was observed in his powers of concentration; he showed that he could give attention and learn readily the assignments made to the class. He was put

into the low fifth grade on trial when the spring term opened, and in a month or two was sent into the high fifth on trial. He managed to get along, and his teacher reported an improvement in his work. For about half an hour a day he was taught privately, and his coach declares a great difference in his capacity for giving attention and understanding. The boy has changed also in his manner out of school. He gets much more out of life; he plays better, he takes the initiative. He has more interests.

Kirchener compiled a table based on statistics gathered in Prussia, which shows that from the fifth to the fifteenth year there is a rapid increase in the percentage of deaths from tuberculosis. Examination of school children by a competent physician, and, in addition, familiarity with home conditions in suspected cases (this can be ascertained by the school nurse), can do a great deal towards checking the spread of this fatal disease.

Overwork and Worry. — The supervision of a competent physician is necessary to discover cases of overwork and worry among the pupils. Children who ought to be under medical treatment, and perhaps in a sanitarium, are often kept at school because of the ignorance of parents and the ambition of the pupils. Inattention, lack of power of concentration, jerking and twitching, supersensitiveness, and restlessness are nature's warning before the nervous system collapses. A trained eye understands those symptoms, and is qualified to suggest the proverbial "stitch in time"; whereas parents, and even teachers, sometimes regard them as evidences of carelessness or naughtiness, and fail to interpret their significance until they see the unmistakable signs of chorea (St. Vitus's dance), epilepsy, or insanity. (See "Fatigue," Chap. XIX.)

Other important diseases frequently met with among school children are hip disease; chlorosis, or green sickness, in girls; certain lesions of the heart and lungs; obesity; rickets; and occasionally *arthritis deformans* (an enlargement

and deformity of the joints), commonly mistaken for rheumatism.

Deformities. — Deformities may be so obvious that there can be no mistaking the condition, or they may be so slight a deviation from the normal as to escape notice except by careful examination. They fall under two heads: 1. Congenital — such as harelip, cleft palate, clubfoot, supernumerary toes and fingers, webfeet, and congenital dislocation of the hip. 2. Acquired deformities — as flat foot, frequently resulting from rickets; bowlegs and knock-knees, often due to the same cause; and hernia. Many of these are capable of rectification during the plastic years of childhood. Early treatment may effect a complete cure, or, at least, make the deformed parts of less hindrance to future activity.

Malnutrition. — There is no condition which calls for the constant supervision and advice of a competent physician more than that known as malnutrition or improper nourishment. It depends as often upon improper as upon insufficient food. Rich and poor may suffer equally; the one from overfeeding and improper feeding, the other from lack of food. It is perhaps the most difficult condition to deal with, as it involves to such a large extent conditions in the home from which the child comes. In these cases, the school nurse is particularly helpful. While the duty of the medical inspector is merely to detect the disease, notify parents, and advise treatment, the nurse can accompany the child to its home, give friendly and helpful instructions regarding diet, exercise, clothing, sleep, bathing, overexertion, and general hygiene.

Contagious Diseases. — The most common contagious diseases to which children are susceptible are parasitic diseases of the head, mumps, measles, whooping cough, contagious eye diseases, chicken pox, scarlet fever, and diphtheria. The last two are the most serious. If medical inspection of schools bore no good fruit except in controlling epidemics, money and time would be well spent. Where there is no

inspection of schools, children come for days from homes where contagious diseases exist. They may not be ill, but they transmit the germs in their clothing or their books. It often happens that children attend school when actually suffering from a contagious disease, the mild form not being recognized by inexperienced eyes. But a mild form in one child may produce a severe form in another. Frequently, children reënter school after a siege of contagious illness, or come from homes that have been under quarantine, without having been properly examined as to the danger of transmitting the disease to others.

This could not happen in a school under the supervision of a competent physician. Children from homes where contagion is suspected would be carefully examined and excluded until it was proved that there could be no danger conveyed to the school through such pupils. Mild cases of disease would be detected in the routine examination, and immediately excluded, and the necessary measures of disinfection taken. No child who had suffered from a contagious disease would be allowed to reënter school until cultures or other examinations showed him to be free from the germs of the disease. The value of medical inspection in the case of contagious diseases cannot be overestimated.

General Sanitation. — One other important work calls for the supervision of a competent medical man; viz. the discovery and correction of insanitary conditions which too often are neglected until irreparable harm is done. Many cases of defective eyes are due to improperly lighted schoolhouses. Poor systems of heating and ventilation are responsible for cases of weak lungs and a very large percentage of anæmia. The improper control of dust from floors and blackboards causes or, at least, aggravates catarrh. Malaria and rheumatism often result indirectly from bad drainage, imperfect plumbing, dark basements, ill-kept closets, and other unhygienic conditions.

The advice of the school physician is of value to the superintendent and teachers in regard to the grading of pupils, home study, recess periods, exercises tending to correct abnormalities, athletics, and playgrounds.

To summarize — a system of medical inspection of schools should be established in every community.

I. As a measure of prevention. An intelligent physician will recognize evidences of disease, and the causes thereof. It is much easier to check diseases at the beginning than after they have become well developed. Prevention is superior to cure.

II. As a matter of economy. (*a*) There would be a saving of time on the part of pupils, parents, and teachers — time otherwise lost by sickness. (*b*) Children kept healthy, the process of instruction would be more rapid and effectual.

III. Curative benefits would follow medical inspection of schools. Incipient diseases would be discovered, and those not far advanced would be checked and cured.

IV. Medical supervision will do much toward solving the problems of school government. If children are vigorous and well, there will be less mental dullness, falling behind in grades, dislike of school routine, and truancy.

V. Medical inspection would be a valuable means of educating the public. It would ultimately make the common laws of health universal; it would tend to make men and women study their environment, and the influences affecting it; it would teach them to lead purer and better lives, and put the emphasis on keeping well.

The subject of medical inspection of schools is not a new one. In Paris, as early as 1833, there was an attempt by law to see that schoolhouses were kept clean. In 1842 it was ordered that, "All public schools should be visited by a physician, who, in addition to inspecting the buildings, should also inspect the general health of the children." As late as 1879 these physicians were not paid. The present system of in-

spection in France dates from 1884. The school physician is appointed for a term of three years with an annual salary of 800 francs. Each doctor has from fifteen to twenty schoolrooms which he must visit twice a month. In addition to the examination of children recommended to him by the teachers, he takes the names of pupils absent on account of illness. A certificate of recovery from the attending physician is required before such children can reënter school. He also inspects the school premises with an eye to cleanliness, heat, light, and ventilation. Once a month he examines each child's eyes, ears, and teeth. If these are found defective, the parents are notified, and treatment recommended. In addition to the thorough system of medical inspection instituted in Paris, the municipal authorities provide beneficently for the needy sick and poor children. Glasses are furnished when necessary; midday meals are supplied to the children free or at cost; shoes and clothing are supplied when needed; homes are maintained in the country, and at the seaside for weak, debilitated, and sick children; medical attendance is furnished when necessary. Paris has learned what all educators must sooner or later come to see, that it is folly to try to instruct children when they are cold, or hungry, or sick.

The little country of Switzerland has a fully organized system of medical inspection. Mr. A. J. Pressland, one of the Masters of Edinburgh Academy, in his evidence before the Royal Commission on Physical Training (Scotland), gave details both of the system of physical training prevailing in the Swiss schools, and of the system of medical inspection. I quote from his report: "Medical examination of children and inspection of school buildings are instituted by the Cabinet. These have been for a long time systematically carried out in Zurich by the Central School Board. The Council of Education issues by-laws as to buildings and inspection by the Board of Health. Permission to occupy new schoolhouses must be obtained from the latter. The medical examination

of children is prescribed on their first arrival at school. A child mentally deficient may be referred to a special class or a special institution. A child insufficiently developed may be sent to a kindergarten, or transferred to the list of the succeeding year. The authorities have power to order a reexamination of any school at any time. The examination may apply to buildings as well as to pupils. The Central School Board of Zurich has instituted reëxaminations, as regards sight and hearing, for a number of years. Lately, it has ordered an inspection of teeth at the age of twelve. The advocates of these examinations wish to insure a proper attention to eyesight and hearing at the age of six; to eyesight at the age of twelve when the eye begins to grow fast; to the heart at the same age for the same reason; and to the teeth at twelve, since at this age decay makes rapid progress.

"The report for 1901 of the Central School Board shows that at the age of twelve each pupil has on an average three to four decayed teeth. To overcome the difficulty with teeth, the Board advises:—

"I. The issue of a pamphlet on the care of teeth to every pupil entering the school. This pamphlet the pupil gives to his parents.

"II. Occasional reference to the necessity for care of the teeth by the teacher during class hours.

"III. The grant of medical assistance to poor parents."

Berlin, a representative city of a country that has done much toward providing for its defective children by maintaining *Hilfsschulen*, or Auxiliary Schools, has a satisfactory system of medical inspection. The duties of the school physician are:

I. The examination of children as to their state of health before they enter school.

II. In cases of bodily or mental abnormalities, he may recommend the adoption of special instruction.

III. He must look after children who are absent from school without sufficient reasons.

IV. He is to advise the headmaster in cases of infectious diseases.

V. He is to notify the School Board when he finds the health of the children unfavorably affected by the unhygienic conditions of a school.

VI. He is to be present at a certain hour at the school twice a month so that the master may obtain his advice in individual cases.

VII. All medical officers of schools must meet regularly under the presidency of a member of the School Board to discuss matters relative to the hygienic conditions of schools.

VIII. The school physician has control of the classrooms without reference to the hours of instruction.

These duties are complex, and it requires tact to avoid friction with teachers and family physicians; but in charge of competent men, the system has been pronounced successful wherever tried.

"In England, the school boards generally provide for medical attendance on their teachers and pupil teachers, for the regular visiting of their schools, for the dovetailing of medical school inspections with the regular work of the public health organizations, and, generally, for the discovery of infection among school children, and the prevention of infection by detailed periodic examinations of school premises. In many public schools, more especially where a boarding system is in force, medical inspection has gone much further. Such schools retain the services of a medical officer whose duty it is to examine all pupils admitted, to ascertain their fitness both for the mental work of the school and for the physical training required, to attend any cases of illness that may arise, to arrange for the isolation of infectious diseases either within premises provided by the school or in the hospitals of the local authorities, and to report, from time to time, to the governors any circumstances that may imperil the hygienic safety of the children. In the industrial schools, too, which are under control of the Home Office, the managers appoint a medical officer whose duty it is to attend any cases of sickness, and to exercise a general supervision over the health of the school children. In many other schools, even where medical practitioners are not retained, it has become the custom systematically to measure, weigh, and examine all the pupils admitted, and from time to time, all pupils in attendance." [1]

[1] McKenzie, *The Medical Inspection of School Children.*

Other foreign countries, including Japan, Egypt, and Norway, have more or less completely developed systems of medical inspection. Brussels and other Belgian cities have excellent systems. In the little town of Vercelli, Italy (population 25,000), the city government provides free meals for pupils attending the public schools. Every child must attend school and partake of these meals unless he shows a physician's certificate stating the prescribed diet would be injurious. Medical inspection is also compulsory, and is accompanied by free medical attendance.

In our own country, Boston was the first city to develop a system of medical inspection. It went into operation in the fall of 1894. Other towns in Massachusetts adopted the idea, public sentiment became strong in its favor; so, in 1906, the bill requiring the appointment of school physicians in each town and city, and making annual examination of all the children compulsory, passed the Legislature with little opposition. In Boston, the Board of Health appoints the school physicians and directs their work. These men are paid from the public health appropriation. In some towns in Massachusetts the work is under direction of the school committee. The bill outlines the aim of medical inspection as:

I. To discover infectious diseases.

II. To ascertain whether the child is suffering from defective sight or hearing, or from any other disability or defect tending to prevent his receiving the full benefit of his school work, or requiring a modification of the school work in order to prevent injury to the child or to secure the best educational result (Act of 1906, Ch. 502, Sect. 5).

In order to give some specific notions of what typical cities in various parts of our country are now doing in the way of medical inspection, the following excerpts are taken from the reports of the superintendents of the cities mentioned: —

Birmingham, Ala. — "Whenever a case of contagious disease makes its appearance in the school, all pupils in that family, or all who have been

exposed, are withdrawn from school in accordance with the schedule prepared by the board of health. The health department promptly reports to the office each case as it appears . . . and the principal of the school is at once notified. Usually the principal has discovered the case and taken action prior to the receipt of the official notification. . . . The medical inspector gives no treatment. By a card system the parents are advised, through the principal, to consult their family physician or a specialist. If unable to consult a specialist, they are advised to take their children to the Hillman Hospital and Dispensary for free examination and treatment. The board employs trained nurses to visit homes and secure the treatment many parents neglect.

"During the first week of the school year, thorough inspection is made under the joint direction of city health officer and medical inspector, to discover every case of contagious disease. The health officer notifies the principal of each school of all cases of contagion in his district, and the medical inspector reports to the health officer all exclusions for such diseases. Each teacher records, on individual observation cards, all abnormal children, or those who seem so to her. The cards are preserved by the principal until the next visit of the medical inspector, who examines the pupils thus suspected."

Cincinnati, Ohio. — "The medical inspection of schools is conducted by the board of health, who instituted it on Jan. 1, 1907. The district physicians serve as inspectors. All pupils whom the principal or teacher considers in need of medical attention are referred to these inspectors. The recommendations of the inspectors are carried out by the principal, who notifies parents or guardians and excludes from school when directed. When home treatment is not given according to suggestions, the school nurse follows up the case and secures home coöperation. A daily notice is sent to each school by the board of health giving information concerning all the children of the city who are excluded for contagious diseases, and also a list of those who are permitted to return. There are twenty-five medical inspectors and five nurses. . . . In at least 25 per cent of the cases visited by the nurses the coöperation of the home has been secured. . . . The system has now been extended to include the parochial schools of the city. The Odontological Society . . . has . . . a free dental clinic in the school building on Ninth Street, where two dentists are at work from 8.30 until 5.30 each day. Those children recommended for free treatment by the school principals receive attention here. This work is done with the approval of the board of health and the board of education."

Cleveland, Ohio. — "The department of health, through its ward physicians, protects the schools from infectious diseases. During the year

1908, these physicians made 16,225 visits to the schools, examined 51,147 children, temporarily excluded 1798 . . . and treated 6716 cases of communicable ailments. In addition, under the general direction of the school physicians, there have been located in schools in those districts where the foreign element is located, six school dispensaries, five . . . being established in 1909. From these dispensaries medicine is distributed free on the recommendation of the school physician, or at a nominal cost. . . . School nurses . . . visit homes, accompany parents to specialists, and to the clinic."

Detroit, Mich.—"Every school is visited daily by a medical inspector. . . . All pupils who have sore throats, severe colds, headaches, fever, rash . . . or any symptom of disease, are carefully examined. If . . . suspected of having a communicable disease or . . . is physically unfit to remain in school, the pupil is immediately sent home with a recommendation that his parents consult the family physician. In schools in the more congested districts clinics are held at which the medical inspectors and nurses treat pupils suffering from skin diseases or pediculosis. The nurses . . . instruct the parents . . . also accompany parents and children to consult specialists and assist parents in following the recommendations of the medical inspector."

Kansas City, Mo.— "The health commissioner, acting through the physicians whom he has selected to visit the schools, is doing an excellent service. . . . The principal or the teacher finds that a pupil breathes with his mouth open, or does not hear or see well, or looks thin and pale; this child is sent to the principal's office, where the inspector upon examination decides whether the child requires medical treatment or not. If such treatment is needed, the parent is then notified . . . and the family physician takes charge of the case, or the department of health will, at the parents' election, treat the case free."

Minneapolis, Minn.—"A system of medical inspection was inaugurated Jan. 1, 1911, consisting of seven nurses and seven physicians. Eighteen of our graded schools were grouped into seven districts and a nurse and a physician assigned to each. In these, . . . were 11,937 pupils, almost exactly one third of the grade-school children of the city. During the five months that medical inspection has been in operation there have been 19,082 inspections made . . . 7102 were given a physical examination, the balance . . . sent to the inspector as suspected contagious cases, or because they were applying for readmission to school after having been excluded for contagious disease."

Nashville, Tenn.—"Our work was begun in October, 1908. The schools were provided with charts for vision tests, and with such assistance as I [Dr. Roberts, medical inspector] could give, each teacher tested the

vision of the children in her class, except in the high school, where the principal assigned the work to the several hall teachers. . . . If a child's vision was found to be 20–30 or less in either eye, or if, by the teacher's daily observation any other defect of eye, of ear, nose, or throat was found, the teacher sent notice to the parent. . . . After notice had been sent, I visited all the white schools and examined such children as were referred to me by the principals."

Newark, N.J.—"Inspectors shall carefully examine pupils isolated by the principal or teacher, and cause to be excluded those showing symptoms of any contagious or infectious diseases. . . . These pupils are not to return to their classes without being reëxamined by the inspector. . . . They shall supply each pupil with a card provided for that purpose, filled out as directed thereon in ink . . . to be taken home by the child, . . . to the parent or guardian.

"Inspectors shall not under any circumstances prescribe or suggest treatment . . . except in those diseases listed.

"A physical examination shall be made of every pupil before enrollment . . . and a record shall be kept of his findings on the forms supplied by this office. When defects . . . are found which can be removed, a form filled out by the inspector stating conditions and treatment required shall be sent home to the parent or guardian. Inspectors shall make a daily written report to the supervisor of medical inspection.

"Inspectors shall decide all matters of quarantine subject to the rules of the board of health, except in cases of doubt, in which case it shall be referred to the supervisor of medical inspection."

Oakland, Cal.—"The director of the health department advises with the parents, but in no instance prescribes for the child. . . . During the first year (1909–1910) . . . blanks were prepared, and after teachers were instructed in the symptoms of the defects, they were asked to send in the names of those pupils whom they thought needed the attention of the health director. The pupils so reported were given a special examination by the health director."

Providence, R.I.—"In the spring of 1904, medical inspection was inaugurated in the Providence schools. Since March 1, 1909, three inspectors have been employed, and on April 1, of the same year, this inspection was extended to the parochial schools. . . . In 1906 a school oculist was employed. . . . The great part of the work of the school inspectors is with contagious skin diseases and pediculosis. These cases are treated at the city hall, and the material needed furnished by the board of health. . . . In February, 1909, a school nurse was employed. She follows up the cases from the school to the home . . . and also sees that the children sent to the oculist and to the hospital get there. School baths have been

in existence since 1905. . . . Four school matrons attend to the daily baths in the different buildings."

Rochester, N.Y. — "In September, 1909, the dental society offered to assume the responsibility of conducting a dental clinic for the children in the schools. The board of education to provide a room to be used as an office, properly heated, lighted, and cared for. . . . Children are treated at this dispensary upon recommendation of principals of schools. . . . The Society has received permission to open the second dispensary."

St. Louis, Mo. — "The school year of 1909–1910 saw the first actual work of the department of hygiene. . . . A supervisor and five inspectors were authorized by the board of education, Feb. 9, 1909. . . . When the inspector arrives at a school, he at once notifies the principal, who, in turn, through a monitor, informs the teacher that the inspector has arrived and is ready to care for reported cases. The teacher, having previously filled out the teacher's diagnosis card, sends the child with this card to the inspector. The inspector makes his examination and enters his diagnosis on this card and fills out, in duplicate, another form. This he instructs the child to deliver to the parent or guardian. If a child is found to be suffering from a contagious disease, he is at once excluded and the city health department is notified. This terminates the relation of the department of hygiene with the child until he or she is ready to reënter school, at which time the health department notifies us . . . that quarantine restrictions have been raised. The child is reëxamined by the inspector of hygiene.

"In case of . . . physical defect, the diagnosis card [of the teacher] is set back a certain number of days in a follow-up file and at that time the pupil is reëxamined and his condition entered upon the card. Each school in the city has an emergency surgical chest."

Departments of Hygiene. — After due consideration, it seems that the most effective means of developing a system of medical supervision is by organizing a Department of Hygiene, at the head of which is a competent physician, supported by a corps of capable doctors and nurses. Dr. Maxwell of New York City suggests that this physician be given the rank and salary of Associate City Superintendent. His work should be under control of the Superintendent of Schools. There should be no connection with the Board of Health, except that the medical inspectors would report contagious diseases to that

board which by virtue of existing laws assumes control of such cases. The head of the Department of Hygiene should have as assistants a sufficient number of physicians and nurses to guarantee a thorough and continual inspection of the children. The tenure of office of these men should be during competent service and good behavior. Their salary should be sufficiently large to attract competent physicians, else the work will have to be done by inexperienced ones. The same need applies to nurses.

The school physician must be an expert diagnostician, for his work is to detect disease, not to treat it. He should be a man of refinement, culture, and tact, that he may win the confidence of the children who shall come to look upon him as a friend. He must know how to exercise firmness in dealing with parents who do not understand the necessity, or appreciate the value, of his work. He must have a psychological, as well as a physiological and anatomical, knowledge of children. He must be a man of patience, a man who is deeply conscious of his mission — the correction of defects, the prevention of illness, and the alleviation of suffering, thus adding to the sum total of the world's peace and happiness.

A system of medical inspection, to accomplish the purpose for which it is established, should include: —

I. A thorough examination of every child upon entering school. Record should be made of the results of this examination. Note should be taken of the diseases the child has previously had, its race, occupation of parents, physical condition of parents, home environment, peculiarities of the child. Parents should be notified of defects and treatment recommended.

II. Daily morning examination of all children referred to the physician by the teacher, nurse, parent, or the child itself, as seemingly ill; all children from homes where disease of any kind is known or reported to exist; this to be followed by the immediate exclusion of the child when the nature of the disease makes such measures necessary.

III. Examination of all children who return to school, after having been detained at home on account of illness of any kind, without a properly signed certificate of recovery.

IV. Examination of children who reënter school without properly signed certificates from the Board of Health or attending physician, from homes where contagious diseases have existed either in the child or other members of the family.

V. Routine weekly examination, by the school nurse, of the condition of scalp, eyes, ears, teeth, fingernails, nose, and throat. A similar monthly examination by the physician to detect symptoms that might have been overlooked by the nurse.

VI. Examination of children referred by the school nurse for diagnosis.

VII. When contagious cases are discovered in school, the medical inspector should immediately report such to the Board of Health; all children known or suspected to have been exposed being excluded and the necessary measures of disinfection of the building and books effected.

VIII. The school nurse should devote a certain time each morning to the treatment of minor ailments, and the instruction of the children in practical lessons of hygiene. She should, furthermore, be a mediator between the school and the home, tracing diseases back to their causes, and teaching the rudiments of the science of preventive medicine.

IX. The school physician ought to be the guide in all matters of sanitation concerning the school.

X. The medical inspector and the nurse must each be provided with a room in which to work. The physician's office must contain the necessary instruments and appliances for a complete examination of patients. The nurse's room must be supplied with bandages, instruments, and drugs essential in the treatment of minor ailments. There should also be a rest room, where children taken suddenly ill may lie down until arrangements can be made for their removal from the school.

XI. In all questions pertaining to his work, the school physician should be responsible to the Superintendent of Schools only. He should also have the right of appeal to the governing body in case of capricious dismissal.

But with all these points fully developed, the system may yet fail to accomplish much of the good at which it aims. Therefore, I add as the twelfth essential: —

A coöperation with hospitals, dispensaries, dental infirmaries, and charitable organizations, that in cases where parents cannot, or will not, supply the necessary glasses, braces, or whatever treatment, medical or surgical, is needed, the child may still be provided for, and thus put in a condition to profit by the instruction the state is so liberally furnishing.

When such a system of medical supervision prevails universally, our schools will no longer be centers of contagion; the work of our classrooms will be less and less interfered with because of pupils who cannot keep up with the work — pupils who continually fail because they cannot see or hear what is said and done before them, pupils who fail because some disease is sapping away their physical strength and mental vitality. With the physical health of the school children of to-day carefully guarded, we need have less fear for the morals of the coming generation. Much good has already been accomplished. In the last few years, especially in our own country, one detects an inclination toward a universal system of medical inspection of schools.

The hygienic doctrine which gave rise to the modern effort to introduce medical supervision in schools is founded on the belief that prevention of disease is a civic question. The only asset of a state or nation that counts in the long run is honest, intelligent, and vigorous citizenship. Already all the advancing nations of the earth have made provisions for the education of children from the intellectual and moral points of view, and most of those in the lead have likewise provided, in part at least, for the physical welfare of their school children.

The appeal for this kind of help has come in the main from the teachers who have been forced to see that mental and moral progress are very frequently contingent on the physical soundness of the children. Hence the first efforts in behalf of the health of school children had to do with those defects which limited their intellectual progress. Defects in vision were searched out primarily because the children could not get along in their lessons, rather than for the purpose of saving their eyes and health for larger future usefulness. The larger idea of the duty of the school toward physical soundness has yet taken but little hold on the general mind. It seems that only in the very face of a scourge of some dread disease will people act with any sort of vigor. It becomes necessary frequently for the government to threaten quarantine to get preventive measures carried out. Though authorities may know the dangers of a typhoid epidemic, they often refuse or neglect to take the precautions necessary to prevent it. People will drink water taken out of a dirty river, and call it good, even though they know a filthy sewer empties into the river less than a mile higher up. To the ordinary layman clear water is synonymous with pure water.

TOPICS FOR INVESTIGATION

1. Should so-called medical inspection of school children be under the control of the school board, and in the department of hygiene, or should it be under the control of the local health board? Determine the prevailing practice in this regard, and note the advantages and disadvantages of each system.

2. Would it be better to change the name "medical inspection" to "health inspection"? Why?

3. What are the qualifications of a competent health inspector for schools?

4. How is it possible to extend health inspection into rural schools? What is being done in England in this regard?

5. Why have hygiene, the care of health, and preventive medicine made such rapid strides in the past quarter of a century?

6. What conditions in your community are menaces to the public health? Can you arrange your school work to help eradicate such conditions?

7. Make a careful study of the laws and ordinances in some typical cities and towns, relating to medical inspection of the school children.

8. Why have school nurses proved so helpful in connection with medical inspection?

9. Determine, if possible, the relative cost of medical inspection in a typical city, and the saving in doctor's bills and school time directly and indirectly effected thereby.

10. Should school clinics and dispensaries be encouraged? Why?

SELECTED REFERENCES

CORNELL, W. S. *Health and Medical Inspection of School Children.* Philadelphia, 1912. 614 pp., illus.

GULICK and AYRES. *Medical Inspection of Schools.* New York, 1908. 276 pp., illus.

KELYNACK, T. N. *Medical Examination of Schools and Scholars.* London, 1910. 434 pp.

MACKENZIE, W. L. *The Health of the School Child.* London, 1906. 120 pp.

MACKENZIE, W. L. *The Medical Inspection of School Children.* Edinburgh, 1904. 445 pp., plates.

New York Board of Health. *A Bureau of Child Hygiene, etc.* Bureau of Municipal Research, 1908. 40 pp., tables.

STEVEN, E. M. *Medical Supervision in Schools* (Great Britain, Canada, United States, Germany, Switzerland). London, 1910. 268 pp., illus.

ZIRKLE, H. W. *Medical Inspection of Schools.* Boulder, Col., 1902. 66 pp.

CHAPTER XXIII

HYGIENE OF SCHOOL UTENSILS AND BOOKS

Danger of Contagion in the Use of Common Lead Pencils. — In these days, when most or nearly all contagious diseases are known to be due to germs, bacterial or protozoan, teachers have power to forestall disease through cleanliness and disinfection not dreamed of a few years ago. Since slates have disappeared from the schoolrooms, and paper and lead pencils furnished by the school have taken their places, a problem of hygiene has arisen in place of the one discarded with dirty slates. It is a common habit with school children, and even with adults, to moisten the tip of the pencil by putting it into the mouth in order to get a darker line. Where pencils are distributed daily or even weekly from some common supply, the pencil one child has used to-day may be used by another tomorrow, and the germs left by the first picked up by the second. It may be well for the teacher to speak of the habit as unnecessary and filthy, and to caution the children against the dangers incident thereto; still, if nothing more is done, the danger will not be obviated. It has been determined by careful bacteriological studies that not only the tip of the pencil may carry pathogenic germs from one mouth to another, but that the blunt end of the pencil, whether it carries a rubber tip or not, may also in the same way offer opportunity for the spread of diseases, such as diphtheria, tonsillitis, influenza, or even tuberculosis.

Dr. Arnold, after making a careful bacteriological study of school utensils,[1] says: "On Jan. 14, 1897, I secured a lead

[1] *Bacteriological Study of School Utensils*, Dr. Mary L. Arnold, Pedagogical Seminary, v. vi, p. 383, September, 1899.

pencil from the —— school. The pencil was from a box containing pencils that had been collected from a class. They were kept by the teacher until used the next day. Plate and tube cultures were made from it. Great were the surprises which that harmless lead pencil had in store. In a single plate culture from that pencil I counted five hundred colonies. At least nine hundred or one thousand colonies covered the Petri dish. Studies of thirteen colonies demonstrated bacilli and micrococci." There is no reason why, as Dr. Arnold suggests, the pencil tip may not carry germs of pneumonia, tuberculosis, diphtheria, whooping cough, and other virulent diseases from one pupil to another, for, as we have said, the pencil often finds its way into the mouth of a child regardless of whose mouth it has last left.

Proper Care of Pens and Pencils. — It is worth while, therefore, to give some thought to the hygienic use of a common supply of pens and pencils. In the first place out of mere respect for decency and cleanliness, each child should be furnished with a pencil with his or her name on it, so that each child will daily use the pencil belonging to it, and no interchange be allowed. At first thought this looks as if it would burden the teacher. But in the long run it may save time, and it will enable her to locate wasteful and careless use of pencils and thereby furnish her an opportunity to teach a good and definite lesson in civics, for it will make each child responsible for the care of his pencil. The name of a child can be easily written in ink on a pencil, if a thin slice of the wood near the blunt end is cut away. This can be done in such a way as not to harm or seriously disfigure the pencil. The pen stock can be marked in the most convenient place in the same way. Then if it seems necessary to gather up the pencils and pens after use, a simple case can be constructed out of denim or some such material, designed to accommodate in separate compartments as many such articles as would be needed by the pupils in one row of desks from front to back. The pupil

in the rear seat can gather and distribute them when there is need, hanging this simple case on hooks fastened to the back of his seat. By this means no one but the owner of a pencil need handle it, and the pencils will not come into contact with each other.

Occasionally, especially if there are any signs of diphtheria in the neighborhood, it is well to sterilize pen stocks and pencils by emersion for a short time in a solution of one to one thousand mercuric bichloride, or some disinfectant not destructive to them. Danger from diphtheria may exist long after a child has recovered sufficiently to return to school, or even when the child is not sufficiently indisposed to quit school. More trouble from contagion comes in the fall when children return from vacation than at other times, for many may be carrying germs from which they have experienced no difficulty, but which through transference may start an epidemic.

For the same reasons, though in a different way, books, crayons, and especially clay, for modeling purposes, may become agents for spreading contagion. For not only are pathogenic germs often found in the mouths of school children, but nasal discharges, eye infection, and various skin diseases furnish opportunity for contaminating pens, pencils, books, crayons, clay, etc., which will render them not only objectionable, but dangerous for indiscriminate use.

When it comes to the use of common drinking cups, common towels, combs, and brushes, added danger is suggested. The subjects of wholesome drinking water and drinking fountains are considered under a separate heading. (See pp. 51 f.)

Danger from Crayons. — Common blackboard crayons, because of their porous nature and the ease with which dirt clings to them, seem to offer almost ideal conditions for the unclean hands of one pupil to transfer to others samples of many kinds of germs. But chalk dust so polluted not only gets on the hands; it may, and often does, irritate the nose and

throat and in this way may sow the seeds of disease. The simplest precaution one can take with reference to chalk is probably the best one: a vigorous application of soap and water and a clean towel to the hands of those who would use the blackboard. There is, however, good reason why a good quality of crayon should be used instead of the soft, brittle kind usually furnished. A good quality of talc is even better, if slate or glass boards are to be used. Then, as suggested elsewhere, the crayons should rest on a wire screen in the chalk trough so as to separate them from the dust which has already fallen from the board. Colored crayons must be handled carefully, for some of them contain arsenic.

Disinfection of School Books. — Since school books are being furnished in greater and greater numbers to the pupils, the proper disinfection of them has become a rather serious problem. It is a fact, despite all that conscientious teachers can do, that many children come to school with dirty hands, soiled garments, and filthy mouths. Many of them suffering from nasal troubles are not furnished with clean handkerchiefs, and their hands are frequently unfit to handle their own books, not to speak of reference books, supplemental books, and those texts loaned them by the school.

Many methods have been devised to free books from dust and disinfect them; but most of them when effective in destroying germs have been injurious to the books. The most effective method which has come to my attention seems to be that described by Boyer,[1] and from his article the following extended quotation is made: —

"In France Dr. Lop proposed several years ago to disinfect the books of the primary schools every summer; also to disinfect the books, notebooks, and clothes of every pupil attacked by a contagious disease. But how can a book be disinfected without damaging it? Krauz recommends exposure to high pressure steam for forty minutes. The condition of the binding and the pages after such treatment may be left to the

[1] See *Scientific American*, v. ci, No. 4, July 24, 1909, pp. 60–61.

reader's imagination. The original process of Berlioz and Championniere does not seem much better. This process consists in subjecting objects to the vapor of formic and ethylic aldehydes in an oven heated to about 200° F. This treatment continued for two hours completely destroys the most virulent germs (tuberculosis, diphtheria, coli bacillus, etc.) placed on the edges, or even in the center, of the volumes. For example, a large volume of 1300 pages was selected for experiment. One of the middle pages was saturated with pus, and another was soiled with fecal matter. A portion of each of these pages was torn off for use as a control. The volume was then placed in the disinfecting oven and heated for two hours and fifteen minutes to about 180° F. Experiments in producing cultures with the soiled parts gave entirely negative results. Unfortunately, the treatment slightly injured both paper and binding. Marsulan has recently improved this method by the invention of the simple apparatus which is now in use at Montreuil, n the workshops where diseased persons and cripples are employed. In the improved process, the books first go through the beater. This machine is a long box connected at one end to an ordinary stove, and provided at the other end with a door through which open racks containing the books are introduced. Inside the box wooden rods are caused to rise and fall, alternately, by cams placed on a cylinder, which is turned by a crank. A ventilating fan and a sliding drawer complete this apparatus, which is mounted on trestles. When the crank is turned, the rods strike the covers of the books and dislodge the dust. The heavy dust falls into the drawer upon a mass of sawdust, saturated with a powerful disinfectant, while the lighter dust, carried off by the air current, is consumed in the stove. After this treatment, the books are suspended singly by pincers from a series of open metal racks, the covers of the book being bent back. Thus the pages are freely separated, and give easy access to the antiseptic vapor. The racks are mounted on rails, on which they are run into the disinfecting oven. Each of the three ovens employed at Montreuil accommodates two racks of books. The ovens are sheet-iron boxes, hermetically closed. Two sides of the box can be raised by cranks to admit the book racks. In the center of the oven is a vessel filled with a solution of formic aldehyde, into which dips a strip of felt, which can be moved up and down from the outside of the oven. The ovens are heated by steam pipes placed below them, to 122° F. The irritating vapor of formic aldehyde makes its escape through a pipe at the top of each oven. The operation of disinfection is simple. The vessel is filled with formic aldehyde, and the racks laden with books are pushed into the ovens, which are then closed and heated to the required temperature for a few hours. After heating is stopped, the volumes are

allowed to remain in the oven until the next day, when they are found to be entirely aseptic. This improved process of disinfection does not injure either paper or cardboard. It is very efficacious, as has been proved by the experiments of Dr. Mequel, and it is also very cheap, costing only about one half cent per volume.

"The municipal council will shortly be asked to establish new disinfecting plants at various points around Paris, in order to extend the system to all the school libraries of the Department of the Seine. Several foreign cities are about to follow this example."

I have introduced this long quotation describing this complicated process, not with the hope that it can, or will, be used extensively, or even at all, but to show how difficult it is to disinfect books effectively without doing damage to them. The books must be cleaned of dust and the pages must be well separated before disinfection can be effectively accomplished.

In general where there is any likelihood of certain books transmitting contagion these can be segregated, and either destroyed or, by using the principles illustrated in the method described above, subjected to those gaseous disinfectants which will not harm the color or destroy the book. It must ever be remembered that a gaseous disinfectant must have easy access and plenty of time.

Parts of books may be purified by direct sunshine, but this method is impracticable on a large scale.

The safe rule for teachers is to insist that the hands of the children be clean, and to teach them the careful, sanitary use of books and all common utensils of the schoolroom.

Slates are Bad. — There is no longer any excuse for the use of slates in school work. They were almost indispensable for nearly a century, but inexpensive paper and lead pencils have taken their places, much to the relief of all. Slates are noisy, nearly always too dirty to use safely, and always hard on the children's eyes because of the lack of good, clear definition of the pencil marks, and proper contrast between the marks and the color of the slates. They are still found in the rural schools of some states, but have been rapidly disappearing in the last

twenty years. The school boards of nearly all cities furnish lead pencils free, and likewise much of the paper that the children use in their daily work. The school system has gained much from this substitution, but the children have gained more.

It was almost impossible, when slates were used, for the teacher to examine the written work with sufficient frequency and care to give each child the sort of criticism needed. Lessons or exercises written on paper can be examined and criticized out of hours, and better English and more careful work in all lines demanded. Besides, a clear white page of paper will permit no mistakes and errors, without protest. Erasures leave behind them telltale stories of hasty work or careless thinking. A clean notebook sets standards of neatness to which children unconsciously respond. Slates offered small opportunity for successful work in drawing, paper and pencils lend themselves to wide ranges of artistic or mechanical drawing; slates were disgustingly filthy, paper is clean and harmless; slates were noisy, and troublesome to handle, paper is noiseless and always ready. Slates did our fathers and grandfathers a great service, but we are now in a new world educationally, and we have little further use for slates.

TOPICS FOR INVESTIGATION

1. Devise a practical means of preventing miscellaneous use of pens and pencils in schools.
2. Observe the use of modeling clay and devise methods of handling it so as to avoid possible contagion.
3. Devise a simple and practicable method of sterilizing books. Use the suggestions in the method described.
4. What color of writing paper is most restful to the eyes, and at the same time furnishes sufficient contrast with the ink to render the writing most legible?
5. Should all slates be banished from schools? Why?
6. What is the best size and length of a penholder or a lead pencil for children of the various grades?

SELECTED REFERENCES

BEEBE, W. L. *Carbo Gasoline Method for the Disinfection of Books.* Jour. Amer. Public Health Association, v. 1, pp. 54–60.

BOYER, JACQUES. *Disinfection of School Books.* Scientific American, Vol. 101, pp. 60–61. July 24, 1909. Illus.

NICE, L. B. *The Disinfection of Books.* Pedagogical Seminary, v. 18, pp. 197–204. Bibliography.

RENNEY, H. *The Disinfection of Books by Formalin Vapor and by Dry Heat.* Jour. Royal Sanitary Institute, Vol. 31, pp. 46–48.

CHAPTER XXIV

CLEANING SCHOOLROOMS

Vacuum System of Cleaning. — It is now possible to clean by the vacuum system all schoolrooms in cities and towns where electricity or other motor power is available. It is true that vacuum cleaners which are operated by hand are now on the market and can be used anywhere; but while they may be fairly successful for homes and small buildings in general, they are as yet not practicable for the heavier and rougher work of cleaning school buildings. But with a central exhaust or vacuum system installed in the basement and operated by an electric motor or some other equally effective driving power, and a system of pipes leading to all the rooms and halls of a school building, it is possible to clean a schoolroom far more thoroughly than by any other method. And it is hoped that architects will further the movement by installing such a system in all new school buildings. The time is not far-distant when no other system will satisfy, and surely the need for such relief is very urgent. The advantages of this method of cleaning schools may be stated briefly as follows: —

(1) Dirt and dust are removed directly from the schoolrooms and deposited where no further danger is possible. Sweeping a schoolroom only stirs up the dust and spreads it throughout the room on desks, books, ledges, and walls, where it will be again thrown into the air or brought into contact with the hands or clothing. An exhaust system when properly installed and managed stirs up no dust, but through suction gathers it from the floors and walls, carries it to a central deposit or flue preferably in some convenient part of the basement, and thus effectively rids the room of dust.

Courtesy of the Spencer Turbine Vacuum Cleaner.

FIG. 51.

(2) Such a system makes it unnecessary for janitors to go over a schoolroom twice before it looks clean. The exhaust or vacuum method therefore will save time. There are still some practical difficulties in the operation of this system, but it has already proved very helpful and gives promise of much larger usefulness.

(3) Much of the dust brought into schoolrooms is picked up by the shoes of the children when on the streets, in alleyways, from unkept sidewalks, or the open public roads. A microscopic analysis of this dust discloses lint from clothing, bits of excreta from horses, dogs, or other animals, decaying vegetation, in fact all the rubbish of the outer world, and to such particles pathogenic germs are very frequently attached. When air laden with dust of this type is breathed, it not only irritates and clogs the air passages, but offers opportunity for infection, especially from the germs of tuberculosis and other diseases of the respiratory tract. When schoolrooms are cleaned by the vacuum system, and sufficient pure air filtered of all dust is furnished, then, and not until then, can we expect to get rid of the dust nuisance in schools.

(4) The vacuum system makes it possible to clear the walls and ceiling of a schoolroom of dust without marring them and without throwing a cloud of dust into the air.

Other Methods of getting rid of Dust. — Where it is impossible to secure the necessary means for this method of cleaning, the next best thing is to scatter clean dampened sawdust on the floor, and by the use of a fiber brush broom, cause it to gather the dust from the floor. There are now on the market, for the purpose of accomplishing this end, numbers of patent dustless preparations which consist in the main of oiled or waxed sawdust mixed with some disinfectant. When such is spread on the floor and carefully pushed along, the dust particles adhere to the oily particles of wood and at the same time the floor absorbs some of the oil or wax. But a janitor with the least gumption and a little

specific direction from the principal or superintendent can make his own "dustless" preparation. The use of oil on floors as a means of preventing dust from lifting into the air is discussed elsewhere, and needs no further consideration here.

Scouring Floors. — Frequent scourings of schoolroom floors is to be deplored when the floors can be kept in a wholesome condition without it. The swellings and shrinkings due to the scrubbing of wooden floors will in time split the grooves, draw the nails, and roughen the surface of the floors. Floors that have been well cleaned and then kept oiled or waxed seldom need scrubbing.

Removing Ink Stains. — One of the most serious blemishes to schoolroom floors arises from spilled ink. If, however, the floor is kept well oiled or waxed, and the pupils are instructed to absorb the ink quickly by means of ashes, fine sawdust, or even dust from the road (fine sawdust ought to be kept ready for such emergencies), the stain will be minimized. But the matter of removing ink stains after the ink has thoroughly settled into the wood is not so easy. Perhaps one of the best methods is to wash the stained part and then, after scrubbing it dry, treat it with a saturated solution of oxalic acid. If this is applied hot, it will give better results. Care must be taken to prevent this acid from coming in contact with the clothing.

Sweeping Schoolrooms. — For all kinds of schoolroom sweeping, the hair or fiber brush broom is much to be preferred, as it lifts less dust, and is much more useful under school desks than an ordinary broom.

TOPICS FOR INVESTIGATION

1. Gather up the results of the bacteriological examinations made on the dust of schoolrooms. Determine how many of the facts thus disclosed ought to be taught to your pupils in order to give them reasons for being careful at school and at home.

2. Experiment with sawdust dampened with some odorless oils in order to determine what sort of dustless sweeping compounds can be made at little expense.

3. What sort of inexpensive but effective mat or shoe cleaner can be made for rural schools?

4. What sort of surface is best for playgrounds, in order to render them safe and comfortable as a place for play, and at the same time to prevent dirt and sand from clinging to the shoes of the children?

5. Experiment with the various so-called sanitary dustcloths and mops now advertised. Try using on the furniture a cotton flannel cloth with a little floor wax on it, rubbing afterward with a clean cloth.

6. If sawdust is not available, bits of dampened newspaper may be used to gather up the dust. Try it and note the results.

SELECTED REFERENCES

COOLEY, R. L. *The Vacuum Cleaning of Schoolhouses a Special Problem.* American School Board Journal, v. 43, pp. 18–19. July, 1911.

HORTON, E. G. *When and how should Schoolhouses be Disinfected?* Ohio Sanitary Bulletin, v. 6, pp. 246–250. May, 1902.

SHÄFFER, C. G. *Sweeping and Cleaning Schoolhouses.* An Experiment in the Use of Oil for remedying the Dust Evil. School Exchange, v. 1, pp. 440–441.

Wisconsin Journal of Education, *Sweeping the Schoolroom by a Dustless Process,* v. 41, pp. 28–30. January, 1909

CHAPTER XXV

QUALIFICATIONS AND DUTIES OF A SCHOOL JANITOR

More Intelligent Janitor Service Demanded. — The evolution of the school janitor gives many side lights on the ideals dominating public school education and shows in a more or less definite way the main features of our growth toward better adaptation and more effective specialization. Once almost any sort of building was considered good enough in which to hold school, and any one who could sweep and make a fire was considered competent to be a janitor; but along with the progress in regard to school buildings there have come larger and more varied demands on the janitor. A mere sweeper and builder of fires is as much out of place now in a well-equipped school as Squeers would be as principal of a modern high school.

The evolution of the janitor illustrates in a clear manner the general professional uplift that has characterized, in recent decades, the whole school question. His duties have developed from those that any unfortunate widow or cripple could perform to those of a responsible, intelligent officer with technical knowledge and definite skill in handling various kinds of machinery. Many school boards and some superintendents are not yet conscious of this new standard for janitors, and the reason for inserting this chapter is a desire to impress, especially on school boards, the necessity for more intelligent service in the management and care of the complicated equipment of a thoroughly up-to-date school building.

Qualifications of a School Janitor. — What, then, are the necessary qualifications of the janitor, as fixed by the demands of a thoroughly hygienic school building?

A Clear Understanding of the Need of Fresh Air. — He must be intellectually able to comprehend the need of fresh, clean air, and he should know the amount each room must have in order to keep it wholesome. He should understand these matters so thoroughly that no excuse can be found for negligence. It is not enough for him merely to know how to start fires and to set a fan running, for intelligent, purposeful management is absolutely essential to warrant the successful operation of a modern system of ventilation.

Training and Skill in handling Machinery. — He must be sufficiently trained in mechanics to be able to handle electric motors, gas and steam engines, electric switchboards, thermostats, ventilating fans, and various kinds of heating furnaces. It is very wasteful to go to great expense in supplying a school building with such important apparatus, and then to put them under the care of one who does not know how to use them and therefore cannot fully appreciate their purposes. A mere "rule-of-thumb" worker, either in school or out of it, can never be counted on in emergencies, not even in unusual situations.

It may be argued that it is a part of the business of a principal to guide, direct, and inspect the work of the janitor, and therefore all that is needed is a willing worker. True, the janitor ought to be subordinate to the principal and with him work to surround the children with the most healthful and invigorating environment possible; but a principal who has charge of a thousand children ought to be relieved of the details in the oversight of those sanitary affairs. The principal must inspect frequently and advise when advice is needed, but his time is too valuable to spend much of it in the basement.

Not long since, I spent some hours in the basement with a very kind and obliging janitor. He was proud of the new and handsome building for which it was his duty to care, and he was most willing to do anything to keep it clean and wholesome. It was equipped with the plenum system of ventilation, a

hot-air system of heating, and the temperature of the rooms was to be regulated by thermostats. But this man did not and apparently could not understand the principle of the thermostat, and hence could not tell when they were operating successfully or when they were out of order. It happened that on this occasion two of them were not working properly, and it seemed beyond his power to understand where the trouble was. The principal was a most excellent and capable woman, and, though proficient in her duties upstairs, she too, through lack of interest in mechanical things, had not been able to detect the difficulty. The children were suffering by reason of the ignorance of a janitor, and a part of an expensive equipment was rendered useless for the time, because no one in immediate command recognized the need of replacing a tambour and adjusting a lever to its load.

A janitor must be intelligent and sufficiently trained in mechanics to meet all emergencies and to understand thoroughly all the appliances with which he must deal. By exacting so much mechanical skill from a janitor, I do not mean to imply that he is to take the place of the general school mechanic now supplied in most city or district systems, for the business of the latter is to make scientific estimates, repairs, and changes that a janitor cannot find time to make. But there are many emergencies which a janitor must meet immediately in order to prevent impairing the equipment, endangering the health of the children, and wasting time. A janitor must know how, not only to operate the machinery needed in a modern school building, but how also to repair it. For this purpose he must be furnished with sufficient tools to enable him to meet emergencies, and he must know how to use these tools intelligently.

A Janitor must have a Real Love for Cleanliness and Neatness. — He must have a love for neatness and must know when a room is clean and how to rid it of dust. Under the best of conditions a surprising amount of dirt accumulates daily in busy schoolrooms, and it is no small undertaking to

keep acres of floor space clean, neat, and hygienic. A janitor who relies on broom and feather duster either has no conception of the dangers due to dust, or else prefers to spare himself rather than serve the children. It is certainly false economy, as well as dangerous to health, to neglect the much-used floors of a schoolroom and allow them to warp and roughen, and the cracks to fill with dirt. These openings become the temporary resting places of many sorts of pathogenic germs, which a slight draft will lift to the breathing line. We ought to be very near the end of that period in our school management when a janitor is allowed to stir up great clouds of dust in the evenings with a broom and again in the mornings with a feather duster. It is the business of a janitor to know how to avoid this, and the board of education ought to exact such knowledge as one condition to his appointment. No manufacturing business would employ a man and at once put him in a place of such responsibility unless he knew how to perform in a satisfactory manner the tasks he assumes. But the reader may ask, Where is the janitor to gain this knowledge save through experience? In reply I would say that it would be a good plan to select the most experienced, intelligent, and careful janitor in a city system and require all those who seek employment in this line of work to train during a short period under his supervision. A few days of instruction would be of very great service and would abundantly repay the expense and effort required. If this is not feasible, the principal and superintendent must furnish such instruction. Farther on in this chapter an attempt will be made to set forth a series of rules devised to aid in this instruction.

The Moral Influence of a Janitor. — A public school janitor should be a man of good morals, should have a sympathetic attitude toward schoolboys, and should vigorously discountenance anything looking toward filthy or vicious liberties in the basement or on the playground. A tactful man of this kind can render untold service by a quiet, manly attitude toward the

boys, engendering in them a lasting disgust for vulgar behavior frequently prevalent in schools where there are no men teachers to supervise. Furthermore, the janitor will come into daily contact with the children who lunch in the basement rooms, and to a greater or less extent he must mingle with the boys and exert a guiding influence over them during intermissions and on rainy days. It is needless to say that a coarse, careless, unsympathetic man would either nag the boys or disregard many unseemly liberties.

The General Importance of a Good Janitor. — A superintendent of wide experience, one who has charge of many hundreds of teachers, has recently said, "Next to the principal, the janitor can become the most important personage in a city school." This is not putting it too strongly, but it is almost impossible to get the average school board to take this view. At present the janitor is frequently appointed to his place by ward politics and kept there by the same influence. This condition of affairs must cease, and to this end, school boards and school principals must be educated. The janitor is a school officer, and has to do in a vital way with the health, morals, and progress of the children, and should be nominated by the principal in conference with the superintendent, and without such nomination no one should be eligible for appointment.

The Professional Qualifications of a School Janitor. — It should be the duty of a janitor to keep himself posted on all things pertaining to his profession. Books and magazines ought to be furnished him wherein he can learn of new and better devices for doing his work, and so come to take a real professional interest in his calling. A man who has nothing to commend him but poverty and political pull will seldom make any progress, and is apt to degenerate. You cannot depend on such a one voluntarily to disinfect a room when infectious diseases suddenly appear. Neither can you count on him to make any experiments looking toward better care of

the floors, walls, and toilets. He will do things in a routine way despite changing conditions.

Such are in brief some of the general qualifications of a public school janitor, and the sooner school boards appreciate the importance of them, the less will the health of the children be endangered. It is needless to say that such qualifications demand good pay, and that tenure of position should be secure to those who fully satisfy the demands.

Some Specific Directions to School Janitors. — 1. All wooden floors should be thoroughly cleaned, disinfected, and waxed at least twice a year, or if the floor is so conditioned that it is not best to use wax, a thin coating of "dustless oil" should be carefully spread over it. Dustless oil has proved itself very useful, and the opposition to it has come about almost wholly because, through careless application of it, skirts have been needlessly soiled or ruined. When it is of the proper consistency and properly applied, such a floor dressing will not only preserve the floors and prevent dust from flying, but will also serve as a useful disinfectant or hinderant.

2. Before sweeping any floor, there should be scattered over it a sufficient supply of dampened sawdust, bits of dampened blotting paper, or some preparation of sawdust and distillate, to catch and hold the dust. It is not only dangerous to allow dust from the floors to arise in the air, but it necessitates almost double work to keep the furniture and books clean. Such preparations as "Dust Clean" and other similar combinations seem to answer the purpose. But, if funds will not permit investment in such preparations, dampened sawdust is nearly always available at a minimum of expense and is an effective dust gatherer.

3. It is better to use fiber or hair brush brooms for sweeping, for these do not lift the dust in the air, and they can be better managed among the desks than the ordinary brooms.

4. Feather dusters are a delusion and a snare. They, of course, save time, but they are very objectionable in that they stir up the dust and never remove it. Dust cloths are far more effective, and each room should have a good supply of these at hand. One good dusting with a cloth is worth three with a feather duster. It is, however, only a matter of a short time until all large city schools will be supplied with apparatus for removing dust by suction, and all new buildings ought to be arranged to anticipate this method of sanitation.

5. The janitor should call the attention of the teachers to the condi-

tion of the desks at the beginning of each term and with them help to make each child responsible for all rough usage or ink spots. Clean desks give a dignity and a tone of refinement to a schoolroom that is easily lost if such care is not exercised.

6. Chalk erasers should be thoroughly cleaned at least once a week for all rooms, and as much oftener for the higher grades as the necessities of the case demand. They ought to be taken out of the rooms for this cleaning. Where vacuum cleaners are installed, erasers can be thoroughly cleaned by suction. Chalk troughs must be kept clean of dust, otherwise any possible draft will scatter some of it through the air of the room. Damp sponges are useful for this purpose. This rasping dust is very irritating to the mucous membranes of the air passages and may, in this way, become dangerous to the health of the children and teachers. (See Chap. XXIV.)

7. The blackboards must be sponged clean as often as their use necessitates. But they should never be water-soaked or left streaked.

8. Window shades should be kept in repair so that when drawn they will fit closely to the window frames. They should be rolled up every evening in order that the rooms may be thoroughly flooded with light and get the advantage of any sunlight available between sessions, and also to keep them from curling at the sides.

9. School benches should be securely fastened to the floor and properly placed and correctly spaced. The following directions for placing and spacing the desks will give in nearly all cases the best results for a room thirty-two by twenty-four feet. In rooms for the sixth, seventh, and eighth grades (1) leave an aisle two feet wide next to the windows, one three feet wide between the rear wall and the rear seats, and make the aisles between the rows of desks from front to rear twenty-two inches wide. Place all desks so that a vertical line dropped from the inner edge of the desk top will strike the seat two inches back of its outer edge. Keep the rows straight, looking from the front to the rear. No regular schoolroom of this size and for these grades should be arranged to accommodate more than forty or forty-five pupils. (2) If two or more sizes of desks are to be used, those designed for the smaller pupils should be placed near the windows and, if possible, toward the front of the room. Young children need the best light, the best opportunity to hear the teacher, and the best position to see the board work or any charts the teacher may see fit to display in the front of the room. (3) The teacher's desk should be placed at the end of the room in front of the children, and nearer to the inner side than to the window side. This method of placing the desks will allow forty-five desks designed to suit pupils of these grades. That is, it will accommodate five rows, each with nine desks, and leave an aisle next the black-

board wall opposite the windows four feet eight inches wide clear of the chalk trough, and one from six to seven feet wide in front (The exact width of the front aisle cannot be given because of the variations in the depth of the different styles of desks now on the market.) (4) In rooms for the fourth and fifth grades, leave an aisle two feet wide next the windows, one four feet wide between the rear wall and the rear seats, and make the aisles between the rows of desks from front to rear twenty inches wide. This placing will allow six rows of desks twenty inches wide, and at the same time allow an aisle three and one half feet wide clear of the chalk trough next to the wall opposite the windows. If the desks to be used for these grades are more than twenty-one inches wide, the spacing should be made for five rows of desks, instead of six, otherwise there would not be sufficient aisle space next the blackboard opposite the windows. This arrangement will permit nine desks in each row and leave plenty of room in front. (5) When placing the desks in rooms for the first, second, and third grades, leave an aisle two feet next the window side, one four and one half feet wide between the rear wall and the rear seats, and make the aisles nineteen inches wide between the rows of desks. This arrangement will permit six rows of desks eighteen inches wide and leave an aisle next the blackboard opposite the windows four and one half feet wide clear of the chalk trough. It will also allow nine desks in each row and leave space in the front for sand trays and the teacher's desk. But no more than fifty desks should ever be placed in any one room, and this number of pupils is too great for one teacher to handle and do justice to all concerned. (6) In all cases where the rooms are larger or smaller than twenty-four by thirty-two, the aisle next the windows should not be more than two feet wide, otherwise some of the children will be removed too far from the light. The aisle between the rear wall and the rear seats should be as wide as possible in order to get the pupils near the teacher's desk and blackboard, for this will insure better light, make it easier for the pupils to hear the teacher and to see the work on the front blackboard, and it will also aid the teacher in her management. (7) The teacher's desk should be small and placed at a point at least three fifths of the width of the room away from the window side. This position will, as far as possible, cause all the children in the room to face away from the light when attending to the teacher. The teacher ought not to complain, for, while this position of her desk will cause her to face the light more squarely, she should be willing to do this instead of exacting it of many children, especially since she spends but a small part of the time during the session at her desk.

10. Clean windows give a buoyant atmosphere to the schoolroom and at the same time tend to set standards for the home. A full and generous

equipment of materials and appliances should be furnished every janitor in order to make it as easy and as safe as possible for him to keep the windows in good condition. In such details school boards ought not to be niggardly. Janitor's excuses often stand in the way of efficient service.

11. Keep the fires going day and night in the stacks connected with the closets, if such a method of ventilation is used, in order that no odors may escape into the building. It is not enough to build a fire in the morning and let it die out toward the close of the school day. There must be a constant draft through these stacks. Bank these fires in the evening so that throughout the night fires will be kept going and reverse currents will be prevented.

12. If the building is supplied with automatic flush tanks, they should be set to operate oftener during school hours than at night, for any wasteful use of water will lead school boards to limit the supply. Especial care should be taken to see that all closets are thoroughly flushed immediately after the close of intermissions. Some janitor or teacher would do a good service by inventing a flush tank capable of being regulated by the program clock and thus avoid the danger of neglect and at the same time save the expense of a useless waste of water.

13. No crumbs of bread or food of any sort should be scattered in the building to tempt rats or mice. Keep these pests out at all hazards, for they are dangerous. They carry contagious diseases and are frequently instrumental in causing fires.

14. Burn all waste paper each day, for its accumulation anywhere in the building means danger. It is far better to spend a little money on kindling of a less inflammable nature than to attempt to save by storing waste paper. The furnaces are the safest places in which to burn this material.

15. Inspect all fire-fighting appliances at least once a week to see that they are in good condition and ready for any emergency.

16. The walls of all rooms and halls should be swept clean of dust and cobwebs as often as exigencies demand, but at least three times a term. For this purpose special brushes should be employed and care taken to prevent any smudging or discoloration of the walls. It is a good plan for a principal in conference with the janitor to set definite dates for these special cleanings and to make, at the invitation of the janitor, formal and critical inspection of the building immediately thereafter. A little military formality in such matters is sometimes very helpful.

17. Plenty of mats, scrapers, and other practical means of removing mud from the shoes of the children before they enter the schoolroom will save much time in sweeping and dusting and greatly reduce the wear

and tear of the floors. Even in dry weather an amazing amount of sand and grit will cling to the children's shoes while on the playground, and if no opportunity is furnished for removing it before the schoolrooms are entered, it will be loosened and dropped on the floors beneath the desks. Time and money are well spent in teaching children to maintain cleanly habits, and to preserve public health and public buildings. The janitor must be given authority over the children in this and other matters relating to the care of the building.

18. In fire drills the janitor ought to have a definite program to follow, so that in any emergency he will have his duty clearly in mind, and know how to perform it most expeditiously and effectively. He ought to throw open and firmly fasten the doors of the main exits and then hasten to the fire hose. Some of the larger boys can be designated to assist with the doors and in this way help to lessen the danger in case of necessity. It is the duty of each principal to organize the fire drill in all its details and to see that each one knows by practice exactly what he is expected to do.

19. In the case of electrical storms, all external electric wires connecting with the school building should be "grounded," and during the storm season this should be done every evening after school and connections remade in the morning. This precaution, of course, will not be necessary where there is no doubt as to the safety of insulation, or of the fuses provided. Painstaking precaution in such matters is worthy of official recognition.

20. A janitor has a right to the schoolroom immediately after school, for, if he is delayed in getting started at his work, it will be necessary to slight some part of it. A program for sweeping should be worked out with the principal, and all the teachers and pupils should respect it. Carefulness in these matters will prevent much trouble and insure better hygienic conditions. A janitor's day is necessarily long, but he must not be overburdened through the thoughtlessness of others.

TOPICS FOR INVESTIGATION

1. Make a thorough report on the following: We have reached that stage in the demands of school hygiene where a school for the training of school janitors ought to be established in every large city system of schools. This should be under the direct charge of the engineer of the school system, who should be aided and directed in his work by the superintendent of schools and the school health officer. No one should be placed in

charge of a school who has not made such professional preparation as is here suggested.

The work of school janitors should be standardized, so as to put into their hands such directions and information as will insure definite and adequate guidance.

Rural schools deserve better care, and should have regular and effective janitor service.

The school janitor should be under the direct supervision of the principal of the school, with the coöperation of the engineer and superintendent of schools.

2. Experiment with different kinds of floors and floor dressings, in order to determine which best preserve the floors, and at the same time offer no chance to soil clothing. What oils are most effective in preventing dust, and are most effective as germicides?

3. Carefully study the effect of frequent scrubbings of schoolroom floors. Are they likely to do more harm than good? Compare the effectiveness of oiling floors and of sweeping with some form of dust absorbent.

SELECTED REFERENCES

Boston. *Mechanic Arts High School Course for Janitors.* Manual Training Magazine, v. 12, p. 304.

Burrage and Bailey. *School Sanitation and Decoration.* Boston, 1899. pp. 64–72.

Chancellor, W. E. *Our City Schools, their Direction and Management.* Boston, 1908. pp. 53–57.

Frost, W. D. *Our Short Course for Janitors.* Proc. N. E. A., 1911, pp. 990–992.

Putnam, Helen C. *Efficiency of Janitor Service in Sanitary Care of School Premises.* Journal of Education, Vol. 74, p. 98.

Wilson, G. M. *Standardization of Janitor Service.* Proc. N. E. A., Department of Superintendence, 1913.

CHAPTER XXVI

DISINFECTANTS

Disinfectants for School Buildings. — In the first place a clear distinction between a deodorant and a disinfectant is necessary. Deodorization is the mere neutralization of offensive odors. Disinfection is, on the other hand, the process by which pathogenic germs and infectious material are destroyed or are rendered inert.

Natural Disinfection. — Direct sunlight is the most economical and practical of all germicides. Schoolrooms that are kept thoroughly clean and receive a thorough sunning each day are not likely to need much further attention in the matter of disinfection. Cleanliness and sunshine are worth more than any artificial germicides that can be applied to schoolrooms. In special emergencies, however, artificial disinfecting is necessary.

Artificial Disinfection. — 1. *Sulphur Dioxide.* — This powerful disinfectant has a limited use on account of its lack of penetration. When moisture is present, it is very active in surface disinfection, which is often needed in those schoolrooms receiving little or no sunshine. It is easily applied and the process by which it is generated is a simple one. The room should be tightly closed. A metallic pan or bucket which can be heated should be partly filled with water and placed in the center of the room. Half immerse a vessel in this water by placing it on some incombustible substance, such as a brick. This last vessel is for the sulphur. Heat the water until it boils and then set fire to the sulphur. The sulphur dioxide will result. Sulphur dioxide should not be liberated in a room where there are tinted walls or gilt paper. Colored maps,

charts, etc., should be removed, because it will discolor them.

2. *Formaldehyde.* — Perhaps the most powerful of all the gaseous disinfectants now known is formaldehyde. This material and the methods of applying it are inexpensive. This disinfectant is recommended by physicians and boards of health, and methods of using it for schoolroom disinfection are as follows: —

(*a*) *The Permanganate Method* — *i.e.* forming formaldehyde gas by mixing 300 cubic centimeters of a 40 per cent solution of formaldehyde with 150 grams of potassium permanganate for each 1000 cubic feet of air space to be disinfected. The room should be warm and tightly closed. This method is recommended by Dr. Rosenau of the United States Public Health and Marine Hospital Service. This can be applied easily where the necessary chemicals are readily obtainable. An ordinary pan can be used in which to place the materials, and the reaction which follows will free the gas.

(*b*) *The Stewart Method* — which consists in thoroughly spraying the walls, floors, furniture, etc., with a 20 per cent solution of formaldehyde. This is a very effective method, but is more troublesome to apply.

In the first of these methods penetration is not claimed, and in the latter it is not sufficiently proved to rely upon it wholly. However, if penetration is desired, it can be obtained by using formaldehyde mixed with the vapor of carbolic acid. In this way the tendency to polymerization is entirely destroyed. Dr. W. B. McLaughlin[1] says, "The mixture which results in the best effects is 75 per cent of a 40 per cent solution of formaldehyde and 25 per cent of carbolic acid — 8 ounces of the mixture to 1000 cubic feet of air space."

For the floors, doorknobs, handrails, etc., a 40 per cent solution of formaldehyde can be used. In the case of floors, clean sawdust saturated with this solution should be spread over

[1] *Scientific American Supplement*, No. 1706, Sept. 12, 1908.

them. This should be swept out before the sawdust becomes dry. This process repeated every eight weeks will, in general, keep the floors in safe condition. This method is extensively used in Boston at present.

3. *Bichloride of Mercury.* — Great care should be exercised to guard this poisonous drug if it is kept in the school building. It is often mistaken, on account of its lack of color, for something harmless. It should be colored for identification, say with a few drops of a solution of indigo. It can be used in the schoolroom for disinfecting the furniture, floors, and parts of the clothing. For these purposes 1:1000 solution is sufficient. It must not be brought in contact with metals, for it destroys them. An excess of albuminous substances interferes with its action; for this reason it is not effective in disinfecting excreta.

The foregoing disinfectants are those which are most generally used and recommended. They will usually be found effective. However, in case that these cannot be obtained, the following may be used: 1. For floors, cretosol — a teacupful to a gallon of warm water. This should be applied before sweeping. 2. For wooden handrails and desks, a solution of chloride of lime — teacupful to a gallon of water.

For toilets the following are effective: 1. Chloride of lime — 4 ounces to the gallon. 2. Carbolic acid — 5 per cent solution. 3. Caustic lime — 1 part hydrate of lime to 8 parts water. 4. Mercuric bichloride — 1:1000.

Toilets should be flushed frequently and disinfected with a solution of cretosol, strength of solution as given above. In case any article belonging to a child afflicted with an infectious disease cannot be disinfected, it should be burned without delay.

Disinfectants for School Children. — The need of personal disinfection in the schoolroom is almost obviated by the free use of pure water, clean towels, and soap. Parents should be urged to send their children to school in a clean condition, as this greatly simplifies the problems of school hygiene. In case

they neglect doing this, teachers must resort to other methods, in order to guard the health of the children.

Personal Disinfection. — (*a*) *The Hands.* — Bichloride of mercury in a 1 : 1000 solution may be used. This can be purchased in tablet form, which is so prepared that it is easy to make correct proportion. A 2 per cent solution of carbolic acid is also effective. The presence of albuminous or organic substances do not interfere with its action.

(*b*) "*Sore Eyes.*" — That disease popularly known as "sore eyes" is of bacterial origin and is spread through the agency of flies, the handling of doorknobs and books, and the use of common towels. Diseases of the eyes are highly contagious, and children so affected should not be allowed to attend school. A 40 per cent solution of formaldehyde is good for disinfecting doorknobs, books, and towels which have been infected with these germs.

(*c*) *Buccal Secretions.* — In cases of incipient infectious diseases such as diphtheria, whooping cough, etc., the buccal secretions often carry germs. The mouths of those so affected should be washed with a suitable disinfectant, which can be obtained at any drug store. These secretions when ejected from the mouth should be subjected to a 1 : 500 solution of formaldehyde.

TOPICS FOR INVESTIGATION

1. Should school janitors be instructed in the best means for disinfecting school buildings and school appliances, or should this be left in the hands of the Board of Health?

2. Under what conditions, if ever, should a schoolroom that is well kept be disinfected?

3. What is the best method of ridding children of pediculosis (lice)? In what way can the teacher best appeal to parents to keep children at home when they are so afflicted?

4. When children come to school with "sore eyes," what is the duty of the teacher, not only for the sake of those afflicted, but for those who are thereby exposed to infection?

5. Confer with local health authorities relative to the best means of disinfection for all cases arising in schools.

6. What disinfectants should be kept at schools for emergencies?

SELECTED REFERENCES

ANDERSON, J. F. *The Antiseptic and Germicidal Properties of Solutions of Formaldehyde and their Action upon Toxins.* United States Public Health and Marine Hospital Service, Bulletin No. 39. 46 pp.

McCLINTIC, T. B. *Disinfectants, Their Use and Application in the Prevention of Communicable Diseases.* Public Health Bulletin No. 42. Washington, Government Printing Office, 1912. 46 pp.

ROSENAU, M. J. *Disinfection and Disinfectants.* Philadelphia, 1902. 353 pp., illus.

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